

## What is a Flat-Plane Engine and How is it Different from a Cross-Plane Engine?

By Les Waganer

With the advent of the upcoming C8 Mid-Engine (ME) Corvette, there has been a flurry of discussions and rumors of various engines and engine options and improvements. One of the rumored engine options is the Flat-Plane Engine that uses a Flat-Plane (FP) Crankshaft.

**So what is Flat-Plane Crankshaft?** The Flat-Plane crankshaft has a very simple shape with all the crankpins positioned at either 0° or 180°. When viewed from the end of the crankshaft, the entire crankshaft is seen as a flat plane, hence the name. To the right is a pictorial (courtesy of Wikipedia) of the end-view of a Flat-Plane, V8 crankshaft with a typical firing order. This Flat-Plane engine has a distinct sound as the cylinders fire sequentially on alternating engine banks, producing an even exhaust sound. However it is usually louder than the competing Cross-Plane engines (which will be discussed later).

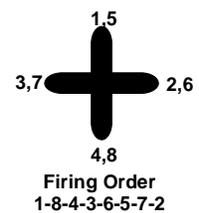


As I understand, the Flat-Plane crank was first used on 4-cylinder engines and continues to be used on most present-day 4-cylinder engines. The following link shows a NASA animation of a 4-cylinder, flat-plane crankshaft engine. <http://www.grc.nasa.gov/WWW/K-12/airplane/power.html> . The illustration shows the operation of a Wright engine that powered the Wright Brothers first successful flight.

The Flat-Plane Crankshaft V8 engines are not typically used in the U.S. automobiles because these engines inherently have more vibrations that are difficult to minimize. However, the Flat-Plane crankshaft needs minimal counterweights, which allows the engine to be lighter, have a smaller crankcase, and (the big reason) can rev quicker and faster (up to 8,000 to 9,000 RPM). This is an ideal engine for racing and super cars. European supercars typically use the Flat-Plane V8 engines. These engines have the uniform exhaust note and a high pitch squeal at high RPMs (revolutions per minute). On naturally-aspirated Flat-Plane engines, the maximum torque is reached at high RPMs, but for turbo-charged engines, the torque is enhanced at low RPMs.

In recent years, the Ford Mustang GT350 engines have adopted the Flat-Plane crankshaft layout to provide a unique sound (in the U.S.) and much higher operating speeds and power. The new GT500 super-charged Mustang does not employ the Flat-Plane crankshaft.

**So What is a Cross-Plane Crankshaft?** - The Cross-Plane crankshaft is used in almost all production V8 engines in America today (including all past and current models of Corvettes). It was developed and introduced by Cadillac (in 1923) and Peerless (in 1924). The Cross-Plane crankshaft engine has each crankpin rotated 90° compared to the previous crankpin. On most modern V8s there are 4 crankpins. When viewed from the end of the crankshaft, the entire crankshaft is



seen as a crossed plane, hence the name. To the right is a pictorial of the end-view of a Cross-Plane, V8 crankshaft with typical V8 firing order.

Cross-Plane V8 engines have unevenly-spaced firing patterns within each cylinder bank that produces the distinctive burble in the exhaust note, but has an even firing pattern, overall. Their non-sinusoidal imbalance, owing to the lack of pistons that move together in a reciprocal phase, is half as strong and twice as frequent as in the flat-plane design, which does have piston pairs moving together. Without a balancer shaft, this cross-plane engine has rotating plane imbalances. However, these imbalances can be mitigated with very heavy and large counterweights. This makes the engine heavier with a larger and deeper crankcase. But the result is a smooth-running engine with a unique exhaust sound.

The unequal cylinder firing on each bank produces the distinctive burble of the U.S. V8 engines. But this unequal firing does not provide efficient exhaust scavenging (on each bank). So long, equal-length exhaust pipes that merge the pairs are needed to achieve uniform scavenging and better engine breathing.

### **The Bottom Line**

#### **Crossplane Crankshaft**

Advantages: Smooth, vibration-free performance (with counterweights) ; distinctive American muscle car burble.

Disadvantages: Heavier (harder to rev), requires larger crankcase.

#### **Flat Plane Crankshaft**

Advantages: Lighter, more compact, more responsive (high-revving), and better exhaust scavenging.

Disadvantages: Prone to vibration, lower torque levels at lower RPMs.

### **References :**

Crossplane (crankshaft engines) <https://en.wikipedia.org/wiki/Crossplane>

Engines Exposed: What is a Flat-Plane Crankshaft?

<https://www.cheatsheet.com/automobiles/engines-exposed-what-is-a-flat-plane-crankshaft.html>

Battle Of The V8s: Flat-Plane Vs. Cross-Plane <https://carbuzz.com/features/battle-of-the-v8s-flat-plane-vs-cross-plane>

Quick Tech: Crossplane vs. Flat Plane Crankshafts Explained

<https://www.onallcylinders.com/2015/01/15/cross-plane-vs-flat-plane-crankshafts/>