How Chevy Went Backward To Go Forward With Its New Corvette Z06 Engine

Old-school engineering means new-school tech in Chevrolet's all-new Gemini Small Block V8.

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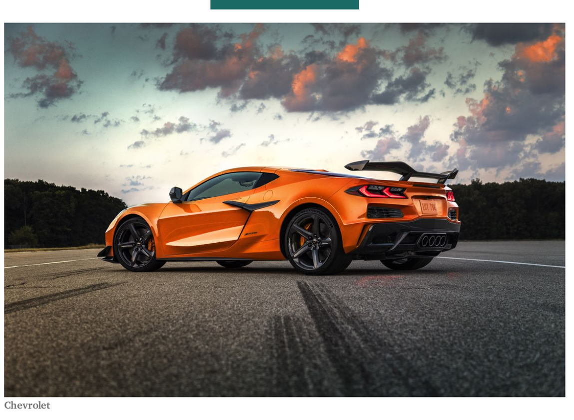
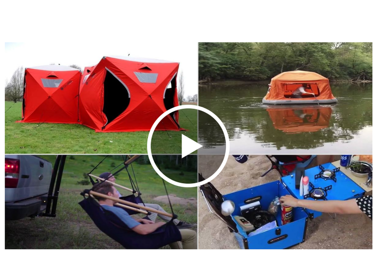


In her 1981 book, *Disturbing the Universe*, the late physicist Freeman Dyson wrote, "A good engineer is a person who makes a design that works with as few original ideas as possible."

Jordan Lee disagrees. He's the chief engineer for Chevrolet's Small Block team, which designed the new LT6 V8 powering the racetrack-focused, mid-engined C8 Corvette Z06. Original ideas, he says, are fine as long as they "earn" their way into a project based on merit.

"We will never implement technology for technology's sake. There has to be a real tangible benefit to the customer for it to be considered." In the case of the LT6—which replaces the supercharged LT4 V8 used in the previous generation (C7) Corvette Z06—consistent power and passion are the tangible benefits.



Chevy's Small Block team realized those advantages by blending the best in state-of-the-art digital design and analysis tools, advanced materials, and proven components with five classical engineering approaches.

Internal combustion (IC) engines are air pumps. Like human beings, they breathe in oxygen and exhale carbon dioxide (CO_2). Starting with Karl Friedrich Benz' single-cylinder "Motorwagen" engine in 1885, early automotive IC engines were naturally aspirated (NA), breathing ambient atmospheric air.

Air density varies with atmospheric pressure, and as development continued through the early 1900s, engineers recognized that denser volumes of air combined with additional fuel and well-timed spark ignition inside an engine's cylinders produced a bigger combustion charge and more power. What if you could force more air into the cylinder?

It wasn't until 1921 that Mercedes forced air into a car engine's combustion chambers using a supercharger, and until 1962 that Oldsmobile became the first to integrate a turbocharger with the Jetfire V8 in its Cutlass. By the 1980s, manufacturers routinely added turbochargers and superchargers to boost power but in smaller displacement engines that prioritized fuel economy.

But from the first Corvette in 1953, Chevy stuck with NA V8s and they made impressive power. The sixth generation Corvette Z06's LS7 V8 pumped out 505 horsepower (hp) in 2007. But less than a year later, a new Corvette ZR1 debuted with a supercharged 6.2-liter LS9 V8 putting out 638 hp. Chevy stuck with supercharging for the next-generation C7 Z06 and ZR1.

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Eight years ago, Corvette chief engineer, Tadge Juechter, gave the Small Block team a new directive. Juechter wanted more power from the next Z06 engine, but he wanted it to be naturally aspirated for more consistent lap times. The C7 Z06's boosted LT4 made a thundering 650 horsepower, but it didn't deal well with high ambient temperatures on the racetrack.

The latest Z06's 5.5-liter LT6 breathes naturally via dual 87-millimeter throttle bodies, an intake manifold, and cylinder heads that Chevy engineers say "hold nothing back." It makes 670 horsepower without a supercharger, turbocharger, or any kind of forced-air induction. "It's the most powerful naturally aspirated V8 engine ever put into production," Lee affirms. "I think it's a bullseye."

Further, it's a bullseye that Juechter and Chevy gave their engineers the freedom to hit, Lee says. "We were super excited that we weren't restricted to anything typical of a high volume production truck or passenger car engine. We were allowed to pick the best technology that we knew of to make the LT6."

The 2023 Chevrolet Corvette Z06 is powered by the 5.5-liter LT6 engine, the highest horsepower, naturally-aspirated production V8 to hit the market.
Chevrolet

Picking the best technology gave Chevy the hot-weather track performance it was looking for. The Small Block team modeled 50 iterations of the new LT6's intake to enable it to flow 33 percent more air than the previous intake. They paired the increased airflow with a more effective cooling system, which incorporates five radiators, a dedicated engine oil cooler, transmission cooler, and a front bumper with a removable aero panel that increases the front grille's opening by 75 percent for track use.

In fact, the Small Block team verified that the new C8 Z06 is capable of running all day at the track with ambient temperatures of 100 degrees Fahrenheit *with* the air conditioner on.

Better breathing wasn't just sought to achieve the uncompromised track performance Chevy wanted. Naturally aspirated engines have a sensory feel often muted by supercharging, Lee says. Going back to NA brought that "soul" back. "Boosted engines can come on really strong and there are some good ones out there including some from GM," Lee says. "But we like to think everything we do with the Corvette Z06 should tantalize your senses, including the engine . . . To me, nothing sounds better than a naturally aspirated V8—it's part of the emotional connection of the LT6-powered Z06 on top of the performance."

One of the headline features of the LT6 is its flat-plane crankshaft (FPC). Often associated with racing cars, the FPC has two pairs of connecting rod journals spaced 180 degrees apart. When viewed from either end of the crank, they look flat. But V8-powered passenger cars have overwhelmingly used cross-plane cranks, so called because their connecting rod journals are spaced 90 degrees apart.

You can hear the difference between cross-plane and flat-plane cranks. The former has a firing order where two cylinders on the same side of the engine fire consecutively during a cycle. The FPC firing order always alternates bank to bank, which allows the engine to spin faster, giving it the high pitched screech of an exotic. With the wail comes vibration arising from the 180-degree journals, which generate significant horizontal shaking. Lee calls them "pain shakers."

Cadillac actually introduced a V8 with an FPC in 1923. Almost a century later, the Chevy team saw the potential to almost eliminate FPC vibration using modern engine mounts and other attenuation technology. They also recognized the passion generated by the high-revving FPC V8 in Ferrari's 458. The team even went through the trouble of buying a wrecked 458 off eBay so they could analyze it.

Thanks to the fact that FPCs can remain balanced with lighter counterweights, they have less rotary and reciprocating mass. That allows them to rev very high. Chevy engineers also shortened the stroke—the distance a piston travels up and down the cylinder—of the LT6 (80 millimeters compared to the LT4's 92 millimeters), further increasing its rev-range to a Ferrari-like 8,600 revolutions per minute (RPM). All that speed allows the LT6 to maximize volumetric efficiency.

"The LT6 is capable of about 110 percent peak volumetric efficiency. It's effectively supercharging itself due to the harmonics and the resonance tuning in the induction system, helped by the flat-plane crank," Lee says. Small Block team assistant chief engineer, Dustin Gardner, puts it another way: The LT6 is a 5.5-liter V8 that effectively breathes as much air as a 6.0-liter V8.

Rear view of 2023 Chevrolet Corvette Z06 on a racetrack.
Chevrolet

The Corvette was long known as the last high-volume sports car with a traditional pushrod V8. It has been an outlier because most sports cars shifted to a dual overhead camshaft (DOHC) design by the 1980s. Often forgotten is the fact that a few years later, so did the limited-production (fewer than 7,000 built) ZR1 Corvette.

From 1990 to 1995 the fourth-generation Corvette ZR1 was powered by a Lotus-designed 5.7-liter V8 called the LT5. Later versions produced up to 405 horsepower and revved to 7,000 RPM. In adopting a DOHC configuration for the new LT6, Chevy not only brings the new Z06 in line with its supercar competition, but goes back to this brief chapter of its history.

Once again, making the engine breathe optimally at up to 8,600 RPM is the reason. It was simply not possible with a single cam, two-valve per cylinder pushrod engine, Gardner says. The DOHC's dual intake ports and dual exhaust ports allow for denser, quicker airflow through the cylinder heads into and out of each combustion chamber. For example, the LT6's cylinder head intake ports flow up to 17 percent more air than the intake ports of the previous NA Z06 (LS7) engine.

A high-revving short-stroke twin overhead cam engine like the LT6 needs valves than can keep up. A condition called "valve float" arises at high RPM when valves that follow the contour of a spinning camshaft lobe to open and close can't react quickly enough. It can be catastrophic, causing the valves to contact pistons or camshaft lobes.

It's a more common problem with hydraulic valvetrains, which use a piston encased in a small cylinder to translate cam motion to the valves. Known for their quiet operation and longer intervals between necessary adjustment, hydraulic valvetrains have been used predominantly by automakers for the last 50 years. But the mechanical valvetrain—which actuates valves via a mechanical cam follower (pushrod, tappet, finger)—reigned from 1900 to about the 1970s.

Because it's a simpler, lighter system that transfers motion mechanically without lag, the Small Block team chose to go back to it for the Z06. "With a mechanical valvetrain you really simplify everything," Dustin Gardner explains. He emphasizes that Chevy applied the latest manufacturing capabilities, materials and coatings to the LT6's system, calling it "a modern interpretation of an old school way to build a valvetrain."

It is so strong—even at 8,600 RPM—Lee says, that the LT6's valves will *never* need adjustment, maintaining the tradition of Corvette simplicity and reliability in a package most exotic cars would envy. "With this set-up," Gardner says, "frankly, the valvetrain is happy well above the speed at which the rest of the engine is designed to run."

Because the camshafts are above the cylinders in a DOHC configuration, twin-cam engines tend to be taller than their cam-in-block pushrod cousins. A taller engine might be tough to fit into a low-slung Corvette, but the Small Block team had a way around that.

Multi-piece engine blocks were common in automotive engines up to the 1930s, but were replaced by simpler, cheaper monoblocs as foundry and machining techniques improved after WWII. However, during the War, the famous Rolls-Royce Merlin V12, which powered the Spitfire and P-51 Mustang, used a three-piece engine block largely to ease rebuilds in the field.

Chevy's new LT6 features a two-piece engine block split at the crank centerline; the two-piece block with its thin lower casting helps shorten the height of the engine, making it easier to fit inside the Z06. The mid-engine layout of the C8 also offers more room than the front-engine compartment in the C7, and no visual obstruction.

The chief motivation for the multi-piece block comes again from the racetrack. Its lower half (crankcase casting) integrates a sealed-bay dry sump system with six scavenge pumps which keeps the crank and the rest of the engine well lubricated under load. Gardner calls the two-piece block the "enabler for the lubrication system"

It helps the Z06 pull up to 1.2 lateral Gs while also allowing the crank to spin in remarkably little oil, reducing drag and windage from the counterweights, making "free horsepower".

Jordan Lee says the "magic" of the LT6 is sprinkled throughout the engine in the smallest of passages and castings that few will ever see. "Yes, we did pull from history," Gardner acknowledges. But the LT6 is not a historical artifact, he says. It's the best answer to the challenge GM's Small Block team was issued.

"When given a task with constraints, most engineers are eager to come up with the best solution," Lee observes. "For us, it was a 670-horsepower NA engine."