Turbos Are Red Hot

Turbochargers turn a combustion engine's searing exhaust gases into greater power density and efficiency. In the past decade, they've become automakers' preferred technology for meeting rigorous fuel-economy and emissions regulations. Here's why:

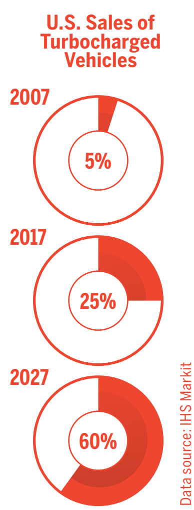
TRENDING

The Replacement for Displacement // Smaller turbo engines are the new normal. //

BY ERIC TINGWALL • PHOTOGRAPHY BY MARC URBANO

Until recently, the preferred method to get a lot of air into an engine without a significant compromise in packaging, cost, or refinement was to have a lot of displacement in that engine. But if you compress the air, you can cram more of it into less space. Fuel-economy mandates now squeeze gas engines hard enough that whole cylinders have disappeared in the shift to smaller displacements. Four-cylinders now do the work of six-cylinders, which have widely replaced V-8s. For all the cubic inches lost, though, forced-induction strategies have come to the rescue, inflating torque curves, preserving performance, and generally saving us from sliding back into a power-starved malaise.

The downsize-and-turbocharge drift began about a decade ago in the lead-up to the stringent Corporate Average Fuel Economy standards established in 2009. Smaller boosted engines are the ideal solution to the cost/benefit equation posed by higher mpg hurdles. Automakers claim up to a 30 percent improvement on EPA fuel-economy labels, and the roughly $250 cost of a turbocharger can be partially offset by savings from shrinking the engine and eliminating cylinders.



As complex and loophole-riddled as they are, CAFE regulations aren't the villains they're made out to be. The same strategies and technologies that stretch a gallon of gas over more miles—fuel injection; 8-, 9-, and 10-speed transmissions; low-friction fluids; and lightweight materials, to name a few—have also made modern performance cars quicker than ever. The turbocharger is no different. It promises better fuel economy with similar performance, or it can deliver greater performance with similar fuel economy.

Those are the claims, at least. On the following pages, we look at hundreds of real-world fuel-economy tests to determine if turbocharged vehicles measure up to their EPA labels. We examine what place the supercharger has in a turbocharged world and how the exhaust-driven turbo will adapt to an increasingly electrified future. And we mount our test equipment to naturally aspirated and turbocharged analogs to better understand what we have to gain and lose as the turbo fundamentally changes the internal-combustion engine. This is our survey of today's new turbocharged normal.

// Stress Test //

A turbo glows red at 1770 degrees Fahrenheit as GM's 1.5-liter inline-four holds a constant 5600 rpm on an engine dynamometer.

A Snail's Case // We butcher a turbo to boost understanding of the species *Cornu aspersum*, a.k.a. the common snail. //

BY DAVID BEARD • PHOTOGRAPHY BY ROY RITCHIE

Ford's turbocharged 2.3-liter inline-four powers everything from the 280-hp Explorer to the 350-hp Focus RS. And variations of this Honeywell MGT22 turbocharger feed that four-cylinder, producing peak boost levels between 16.4 and 22.6 psi depending on the vehicle. A pass through the band saw reveals its inner workings.

Hot Wheel

A twin-scroll design ① separates the hot exhaust gases from sequentially firing cylinders, harnessing the energy in the exhaust pulses to reduce turbo lag as they spin the cast nickel-alloy turbine wheel ② and continue through the stainless-steel turbine housing ③ and toward the downpipe. At high loads, this housing can reach 1800 degrees Fahrenheit and glow red hot.

Spin Zone

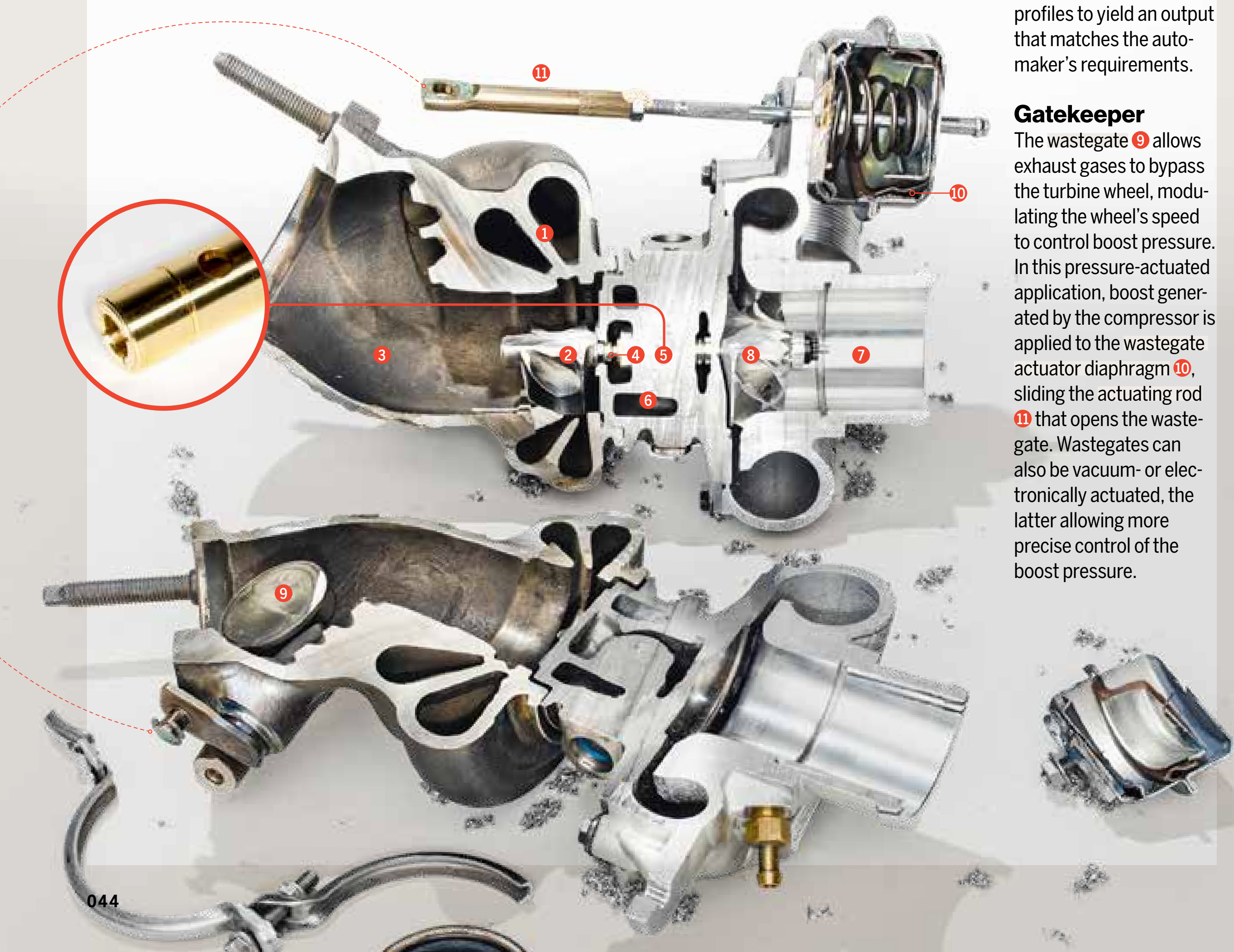
Connected by the common shaft ④, the turbine and compressor wheels spin as fast as 200,000 rpm. The semi-floating copper-alloy journal bearing ⑤ manages the axial and radial loads of the shaft, playing a critical role in turbo efficiency and durability. A coolant jacket ⑥ extracts heat from the center housing to keep oil from coking around the bearing. In exotic turbo systems, more-costly ball bearings reduce friction so the rotating components spool up more quickly and with greater efficiency. Honeywell is also researching oilless air bearings that could further reduce friction.

The Big Squeeze

Ambient air enters the aluminum compressor housing ⑦, and the machined aluminum-alloy compressor wheel ⑧ pressurizes it to create boost. The intake air is then pushed through an intercooler to reduce its temperature (thus increasing its density) and driven into the intake manifold. The pressurized intake charge increases the amount of air in the cylinders, which is matched with additional fuel to create more torque and power. Honeywell offers hundreds of wheel profiles to yield an output that matches the automaker's requirements.

Gatekeeper

The wastegate ⑨ allows exhaust gases to bypass the turbine wheel, modulating the wheel's speed to control boost pressure. In this pressure-actuated application, boost generated by the compressor is applied to the wastegate actuator diaphragm ⑩, sliding the actuating rod ⑪ that opens the wastegate. Wastegates can also be vacuum- or electronically actuated, the latter allowing more precise control of the boost pressure.



Label Makers // Are turbocharged engines a fuel-economy boost or a fuel-economy bust? //

BY ERIC TINGWALL

You've heard the hypothesis before: Turbocharged cars miss their advertised fuel-economy figures more often and by larger margins than naturally aspirated cars. It's a notion repeated so often that it verges on truth by consensus, possibly because it so easily fits with an intuitive explanation: Turbocharged small-displacement engines may be parsimonious on the EPA's feather-footed driving cycles, but keeping up with traffic in the real world requires spooling the compressor and uncorking the fuel injectors.

That's the theory. This is the test.

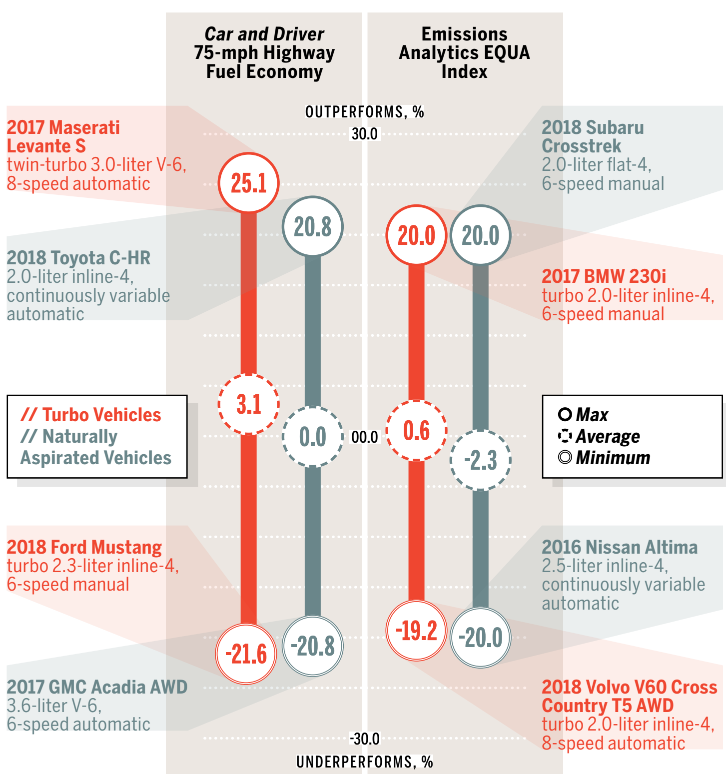
To settle the matter once and for all, we mined two data sets captured from 730 real-world drives of turbocharged and naturally aspirated gasoline vehicles. The first database consisted of 340 vehicles from *Car and Driver*'s highway-fuel-economy test, a 200-mile interstate slog run at an average speed of 75 mph. Analyzing each vehicle's real-world fuel economy as a percentage of its EPA highway rating suggests that the popular belief isn't actually true, at least when it comes to highway mpg. The data reveals that, on average, the 193 turbocharged vehicles we sampled actually beat their window stickers by 3.1 percent. Naturally aspirated models performed worse, only matching their labels on average. Half the free-breathing vehicles beat their EPA numbers, while the other half underperformed according to the label. Among turbo models, 65 percent topped their EPA highway ratings.

Of course, steady-speed low-load highway cruising plays to the strengths of newer downsized and boosted engines that sip fuel while the turbo dozes. To see if boosted engines could stand up to more dynamic driving, we partnered with Emissions Analytics, an independent testing group that publishes its real-world fuel-economy and emissions EQUA Index at USA.EQUAIndex.com. The company uses a portable emissions-measurement system to sample a vehicle's exhaust and derive fuel economy. Its 88-mile Southern California test loop includes both city and highway driving. Emissions Analytics uses a vehicle's EPA combined mileage rating as its bogey.

Surveying the company's 390 tests of turbocharged and naturally aspirated vehicles shows that the trend spotted in *C/D*'s highway fuel-economy data applies here as well. In Emissions Analytics' testing, turbo vehicles beat their EPA labels by a slim margin on average (0.6 percent), and they also fared better than unboosted models, which fell short of their EPA marks by an average of 2.3 percent. Stop-and-go traffic dragged down turbocharged engines, but it did the same thing to naturally aspirated powertrains, too.

The takeaway? On bulk, turbocharged vehicles do live up to their fuel-economy labels. And they don't suffer in the real world any more than naturally aspirated vehicles. That said, there are hundreds of cars, turbocharged and not, that exceed or fall short of the official fuel-economy numbers—some by 20 percent. The data largely vindicates the EPA's fuel-economy methodology, but it's an even stronger endorsement of that old axiom: Your mileage may vary.

These plots show percentage differences between EPA-estimated and real-world fuel economy. We've highlighted the best and worst performers, but the bigger story is in the averages.



The Price of Progress // As automakers turbocharge every segment, some vehicles stand to lose more than others. //

BY ERIC TINGWALL • PHOTOGRAPHY BY ANDI HEDRICK

Progress is rarely victimless. The cotton gin mangles limbs. Robots take jobs. The internet kills common decency.

Even if the tidal shift toward turbocharged engines promises quicker and more efficient vehicles, it will come at some cost. To weigh the price and payoff of turbocharging, we slapped our test gear onto two pairs of naturally aspirated and boosted vehicles. The first matchup situates the modern turbocharging skirmish inside a battle that has raged for more than half a century.

Ford's 310-hp turbocharged 2.3-liter inline-four killed off the Mustang's naturally aspirated V-6 engine in the 2018 model-year refresh. Chevy sells a turbo-four pony, too, but the Camaro's 2.0-liter is significantly less powerful at 272 horses, and frankly, it's impossible to say nice things about that coarse and overburdened lump. Instead, Chevy enters the Camaro's 335-hp naturally aspirated 3.6-liter V-6 into the same fighting class as Ford's turbocharged four-cylinder.

On numbers alone, this is practically a dead heat. The lighter and more powerful Camaro rushes to 60 mph in 4.9 seconds and completes the quarter-mile in 13.6. Packing a 66-lb-ft torque advantage, the Mustang trails by just 0.2 and 0.1 second, respectively. These engines—and the cars wrapped around them—aren't as similar as the numbers suggest, though, because the difference between the blown Mustang and the free-breathing Camaro can't be measured in tenths of a second.

To understand how pressure charging changes a car's character, you have to feel how these two engines rev and accelerate. The first chart on the opposite page quantifies the sensations as best we can with second-gear pulls from 1000 rpm to redline. The Camaro's nearly flat longitudinal acceleration plots the unyielding intensity that's uncorked within moments of flexing your right ankle. The arrow-straight ascent of the engine's revs captures the spectacular linearity of this 3.6-liter climbing to the fuel cutoff, where arriving at 7200 rpm feels practically exotic in the era of modern turbocharged engines that often tap out around 6000 rpm.

The turbo Mustang and naturally aspirated Camaro run neck and neck, but only the Chevy makes that sweet sound.

// 2018 Ford Mustang EcoBoost

PRICE AS TESTED: $30,070
BASE PRICE: $26,580
ENGINE: turbocharged and intercooled DOHC 16-valve inline-4, aluminum block and head, direct fuel injection
DISPLACEMENT: 138 cu in, 2261 cc
POWER: 310 hp @ 5500 rpm
TORQUE: 350 lb-ft @ 3000 rpm
TRANSMISSION: 6-speed manual
CURB WEIGHT: 3556 lb

// C/D Test Results

ZERO TO 60 MPH: 5.1 sec
ZERO TO 100 MPH: 13.2 sec
ROLLING START, 5–60 MPH: 6.0 sec
TOP GEAR, 30–50 MPH: 18.6 sec
TOP GEAR, 50–70 MPH: 9.8 sec
1/4-MILE: 13.7 sec @ 102 mph
FUEL ECONOMY EPA COMBINED/CITY/HWY: 25/21/31 mpg

// 2017 Chevrolet Camaro LT 1LE

PRICE AS TESTED: $41,890
BASE PRICE: $37,395
ENGINE: DOHC 24-valve V-6, aluminum block and heads, direct fuel injection
DISPLACEMENT: 223 cu in, 3649 cc
POWER: 335 hp @ 6800 rpm
TORQUE: 284 lb-ft @ 5300 rpm
TRANSMISSION: 6-speed manual
CURB WEIGHT: 3514 lb

// C/D Test Results

ZERO TO 60 MPH: 4.9 sec
ZERO TO 100 MPH: 12.6 sec
ROLLING START, 5–60 MPH: 5.6 sec
TOP GEAR, 30–50 MPH: 14.3 sec
TOP GEAR, 50–70 MPH: 12.3 sec
1/4-MILE: 13.6 sec @ 103 mph
FUEL ECONOMY EPA COMBINED/CITY/HWY: 20/16/28 mpg

The Mustang revs quicker once the turbo spools and ultimately pulls harder in second gear as it briefly peaks above 0.5 g of straight-line acceleration. But that advantage is just a momentary thrill. The turbocharged yank swells and retreats, a passing wave that can't be captured. The upswing at the low end conveys growing urgency as boost builds. Soon after, though, the engine starts to choke like a sprinter gasping for air halfway through a race. Spinning the engine into the top third of the tachometer, you're often left wondering if you should have shifted sooner. And the dull exhaust note only adds to a general lack of drama. We know this engine can display a bigger personality than it does in the Mustang. The 350-hp version in the Focus RS bristles and charges as if it's running on Red Bull.

Chevrolet's V-6 has clearly been taking voice lessons from the Camaro SS's small-block V-8. Helped by an active exhaust, it lets out a 91-dBA yowl at full throttle, a bellicose challenge to creeping conformity. This engine, one of the last great unboosted sixes around, is proof that turbocharging cuts both ways, particularly when it replaces cylinders in sports cars where subjective traits carry greater significance.

It's a different story in the many affordable mass-market segments where turbocharged four-cylinders increasingly supplant breathy and gutless naturally aspirated fours. While many automakers have already picked turbocharging as the winner, a handful of model lines leave the decision to buyers, offering a smaller turbocharged four-cylinder as an extra-cost upgrade over the base unblown engine or with higher trim levels. These boosted engines typically deliver a trivial advantage in peak power but bring a small nudge on the EPA fuel-economy label and a big bump to low-end torque. You can sample this automotive Pepsi Challenge in vehicles such as the Ford Escape, the Honda CR-V and Civic, and the Hyundai Tucson, which we drafted for this test.

Hyundai's compact crossover starts at $23,530 with a 164-hp naturally aspirated 2.0-liter inline-four. Spend another $4000 for the Value trim (irony comes standard) and you'll step up to a 175-hp turbocharged 1.6-liter inline-four. The turbo Tucson returns performance that far outstrips its 11-hp edge and more than makes up for its considerable 210-pound weight penalty. The naturally aspirated model ambles to 60 mph in 9.6 seconds and begs for mechanical sympathy with a distressed groan that's four decibels higher than the relatively muted turbo engine. At 7.3 seconds to 60 mph, the turbocharged Tucson is legitimately spry.

How is such a large margin possible? The blown Tucson spreads its torque on both sides of the bread, covering 1500 to 4500 rpm with 195 pound-feet. The unboosted 2.0-liter engine musters only 151 pound-feet—and not until it has labored to 4000 rpm. The turbo's torque delivery pays off in the real world, where it accelerates away from traffic lights with more authority, fewer revs, and less audible strain.

You can see it in our 30-to-50-mph passing-maneuver test, as shown in the chart on the right below. Starting from a 30-mph cruise, with both engines turning a neat 1500 rpm, we pin the throttle pedals to the firewalls. The turbo engine's seven-speed dual-clutch transmission and the 2.0-liter's conventional six-speed automatic react with near identical response times. Both grab second gear, and revs surge to roughly 4000 rpm. And then the turbocharged Tucson, helped by shorter gearing, walks away from its naturally aspirated twin, completing the maneuver a full second quicker than the 2.0-liter model.

These Tucsons tell the story of the broader automotive market. Turbochargers are making vehicles objectively better for the masses. It's not so simple for performance cars and enthusiast specials, though. Naturally aspirated engines are facing the same fate as manual transmissions and rear-wheel-drive dynamics, and the consequences are just as unfortunate. As free-breathing engines are squeezed out of the market, we're breaking connections to the mechanical world—the unfiltered fury of combustion, the sustained squeeze of linear acceleration, the adrenaline spike of a tachometer notching 7000, 8000, and 9000 rpm. We're trading emotion for quickness. We're trading what we can feel for what we can measure. That's the price of progress.

You buy the Tucson's turbo 1.6-liter (top) for the fancy engine cover. Better fuel economy and acceleration are icing on the cake.

// 2018 Hyundai Tucson Limited AWD

PRICE AS TESTED: $34,430
BASE PRICE: $31,805
ENGINE: turbocharged and intercooled DOHC 16-valve inline-4, aluminum block and head, direct fuel injection
DISPLACEMENT: 97 cu in, 1591 cc
POWER: 175 hp @ 5500 rpm
TORQUE: 195 lb-ft @ 1500 rpm
TRANSMISSION: 7-speed dual-clutch automatic with manual shifting mode
CURB WEIGHT: 3678 lb

// C/D Test Results

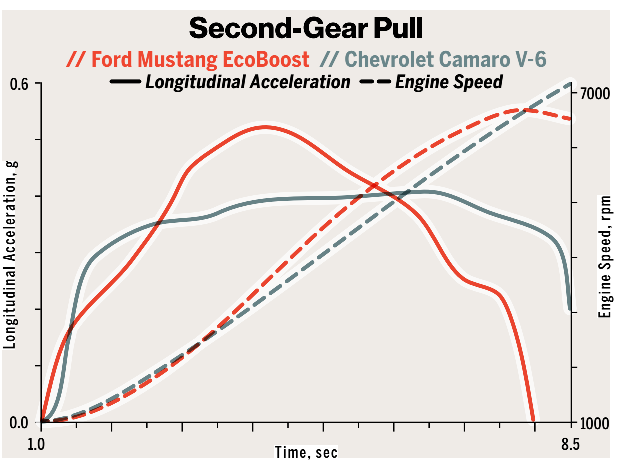
ZERO TO 60 MPH: 7.3 sec
ZERO TO 100 MPH: 21.6 sec
ROLLING START, 5–60 MPH: 7.9 sec
TOP GEAR, 30–50 MPH: 3.9 sec
TOP GEAR, 50–70 MPH: 5.5 sec
1/4-MILE: 15.8 sec @ 88 mph
FUEL ECONOMY EPA COMBINED/CITY/HWY: 25/24/28 mpg

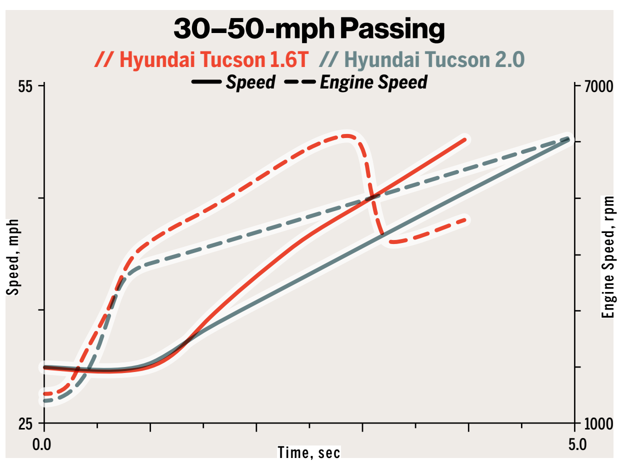
// 2018 Hyundai Tucson SEL AWD

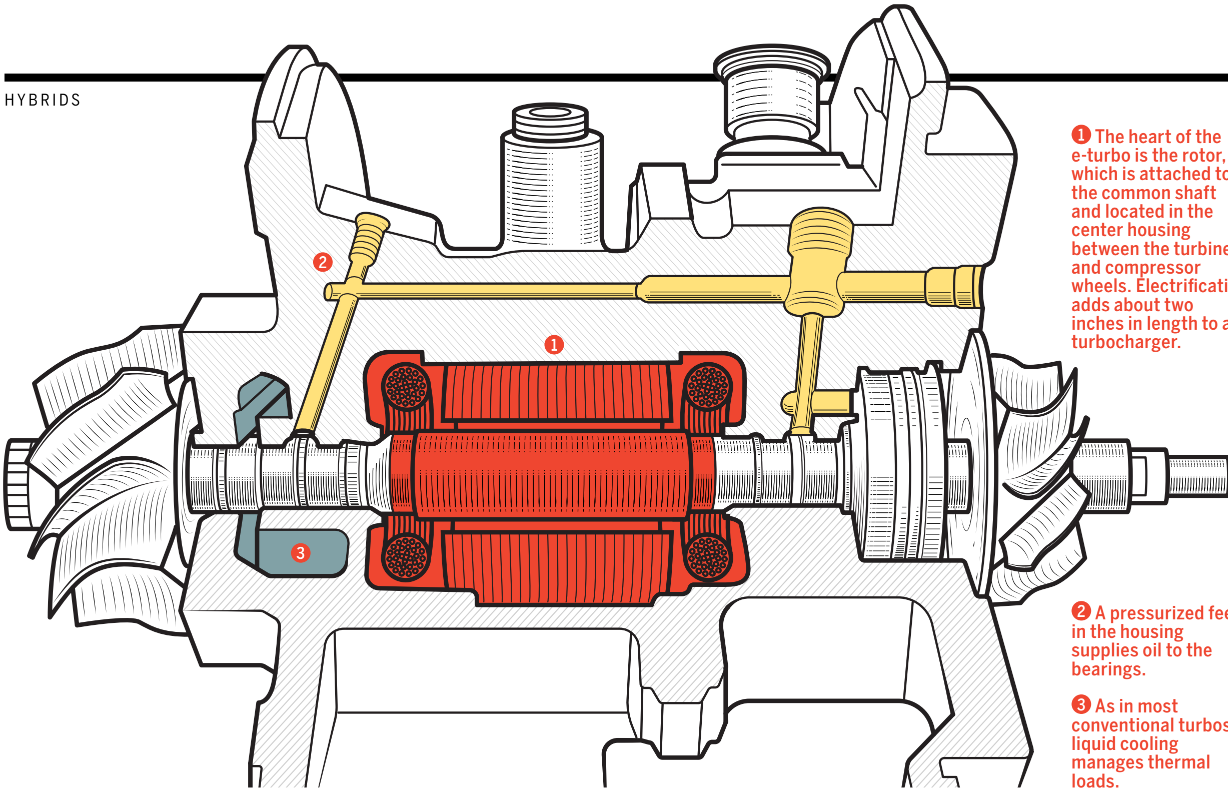
PRICE AS TESTED: $26,630
BASE PRICE: $26,180
ENGINE: DOHC 16-valve inline-4, aluminum block and head, direct fuel injection
DISPLACEMENT: 122 cu in, 1999 cc
POWER: 164 hp @ 6200 rpm
TORQUE: 151 lb-ft @ 4000 rpm
TRANSMISSION: 6-speed automatic with manual shifting mode
CURB WEIGHT: 3468 lb

// C/D Test Results

ZERO TO 60 MPH: 9.6 sec
ZERO TO 100 MPH: 28.6 sec
ROLLING START, 5–60 MPH: 9.9 sec
TOP GEAR, 30–50 MPH: 4.9 sec
TOP GEAR, 50–70 MPH: 7.2 sec
1/4-MILE: 17.3 sec @ 82 mph
FUEL ECONOMY EPA COMBINED/CITY/HWY: 23/21/26 mpg







1 The heart of the e-turbo is the rotor, which is attached to the common shaft and located in the center housing between the turbine and compressor wheels. Electrification adds about two inches in length to a turbocharger.

2 A pressurized feed in the housing supplies oil to the bearings.

3 As in most conventional turbos, liquid cooling manages thermal loads.

Boost with Juice

// Electrification might be the answer to the turbocharger's biggest problem. //

BY JOSH JACQUOT • ILLUSTRATION BY CLINT FORD

Turbo engines are better now than they've ever been. But they are about to become awesome. Most contemporary turbo mills use a turbocharger sized to produce ample torque at low engine speeds. This sizing constricts the turbine wheel and housing, which creates significant exhaust backpressure at high engine speeds. High backpressure increases an engine's tendency to detonate, a problem engine calibrators, until now, often fixed by running richer air-fuel ratios. This strategy increases fuel consumption and emissions. And while using a bigger turbo allows for decreased backpressure, it also results in too much turbo lag. Usefully inserting itself into this dilemma—as well as the space between the turbo's turbine and compressor—is electricity. With an electric motor/generator in the water-cooled and oil-lubricated center housing, so-called e-turbos should allow the use of bigger turbines for high-end power while filling in the bottom of the rev range with electrically driven boost.

Depending on load conditions, the e-turbo's motor/generator can either increase boost by supplementing exhaust energy to drive the compressor wheel or act as a gas-driven generator to turn exhaust energy into electricity that can be stored for later use. Because of their power demands—about seven horsepower on current passenger-car prototypes—electric turbos will initially pair with existing 48-volt hybrid powertrains, which also use a belt alternator/starter or motor/generator to add torque to the wheels and recuperate electrical energy during braking. The powertrain controller will decide among the various options for generating and spending power depending on the requested torque, use scenario, and safety and reliability constraints of the system.

Currently, only one production car on the planet—Mercedes-AMG's Project One supercar—uses an electric turbocharger. The Project One derives its powertrain from the Mercedes-AMG Formula 1 car, and both navigate the cutting edge of gas-electric automotive technology. But a Formula 1 powertrain is hardly the thing to make the e-turbo relevant to the masses. Rather, it's what the electric turbocharger enables—the efficiencies that it unlocks—that will make it matter in 2020 or 2021, when it will likely appear in more-modest performance cars.

According to Rob Cadle, engineering director and electrification business leader at Honeywell, every kilowatt of electricity used to drive the turbo translates to about 10 kilowatts (13 horsepower) of output at the crankshaft. Of course, it's not a free lunch—there's a fuel-economy penalty for making more power with the combustion engine.

But the benefits are numerous for early-adopting automakers that will use e-turbos primarily as performance enhancers, pairing a relatively large turbo with a small engine. Additionally, the e-turbo shows promise as an enabler of more power and better fuel economy by allowing nearly stoichiometric (chemically complete air-fuel) combustion at higher boost rather than the rich air-fuel ratios often used with turbo engines today.

The e-turbo's ability to recuperate power is what sets it apart from the electric supercharger. Both devices use electrical power to fill in the bottom part of the powerband before exhaust energy fully takes over, but because an e-turbo can add electrical power back into the system, its appeal to automakers contending with CO_2 regulations and Corporate Average Fuel Economy standards is ultimately greater.

E-turbos generate electricity in two different scenarios. The first occurs in no-load conditions when the turbo's rotating assembly would normally slow on its own. The second scenario is more clever. By opening the wastegate later or with a smaller opening than would happen in a conventional turbo, the electric turbo uses exhaust energy to simultaneously create boost for the engine and generate electrical power. Again, it's not a something-for-nothing proposition. On-boost electricity generation increases exhaust backpressure. But, says Cadle, there's a sweet spot where the energy extracted from the e-turbo during this type of regeneration is higher than the penalty paid in fuel economy and CO_2 emissions.

On passenger-car engines, e-turbos are not yet fully proven as net-zero energy devices—ones that produce as much power as they consume. Even if that's not the case, they will contribute to a hybrid system that delivers more power and better fuel economy than was available without them.

Under Pressure // The experts explain how boost pressures have tripled over the years. //

BY ERIC TINGWALL • PORTRAITS BY TIM McDONAGH

Oldsmobile's 1962 F-85 Jetfire injected "Turbo-Rocket Fluid"—a mix of methyl alcohol and water—just downstream of the carburetor to stave off catastrophic detonation as its turbocharger peaked at 6 psi of boost. Today's performance cars routinely cram more than 20 psi into their cylinders—no Turbo-Rocket Fluid required. Here, turbocharging experts describe the advancements in recent decades that have allowed automakers to drive boost pressures higher while improving reliability and reducing lag.

"The level of depth that we can get into in computational fluid dynamics simulations, in mechanical simulations, and then being able to run those many, many times to come up with an optimized design—we didn't have this capability 10 years ago. It's helped a lot in the turbocharger design, but our customers are also using this capability to design the engine, the cylinder head, the shape of the piston bowl, and so on." ***—Craig Balis, vice president and chief technology officer, Honeywell Transportation Systems***

"Heat rejection is a big deal. There are two aspects to that. One is cooling the incoming air charge because obviously we want to make the air as dense as we possibly can. The other side of the cooling is to take the heat away from all of this power that we're now creating inside the combustion chamber. We don't want to generate too much heat inside that process or we're going to run into pre-ignition-type problems." ***—Peter Dowding, chief engineer, global engine engineering, Ford Motor Company***

"If you make the turbo big enough, you can put a lot of boost pressure into the engine. You have to make sure you still have a good response. That was the biggest challenge. For the turbo, the biggest improvements were actually the aerodynamics on the compressor and the turbine. It's just the way we design it, the materials we use for it. So it allowed us to make the turbine and the compressor run faster, run harder, but make turbo components smaller, and thus have lower inertia and a better time to torque." ***—Hermann Breitbach, vice president, global engineering and innovation, BorgWarner Turbo Systems***

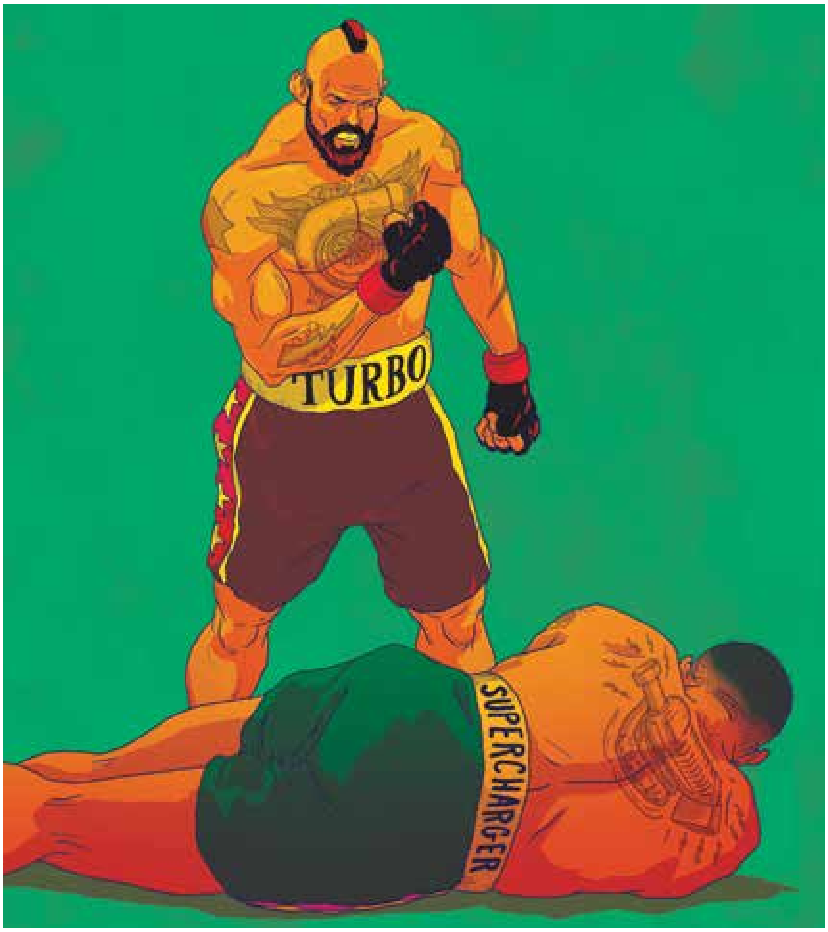
Taking Charge // In the battle between Super and Duper, there's a clear winner. For now. //

BY JARED GALL • ILLUSTRATION BY MICHAEL BYERS

Forced induction is an increasingly necessary means of getting more out of an engine. But in 2018, forced induction increasingly means turbochargers, not superchargers. According to the data specialists at IHS Markit, some 220 cars and trucks on sale in the U.S. today offer at least one turbocharged engine, compared with just 30 models with supercharged offerings. Both means of forced induction have their drawbacks, but turbos are winning because engineers have been better at mitigating the turbo's many issues.

While superchargers have traditionally been more responsive at the low end, turbochargers have benefited from numerous recent improvements in engine design. Hot-V setups place the turbos closer to the exhaust valves for faster spool-up times. Twin-scroll turbine wheels harness exhaust pulses more effectively. Even the turbine and compressor wheels within those turbos are being designed for greater power and quicker response and are benefiting from advances in metallurgy, such as the titanium-aluminide turbine wheels in Cadillac's new twin-turbo 4.2-liter V-8.

On small inline engines in tight engine bays, turbochargers package more naturally. They integrate easily into the exhaust system and, according to the powertrain engineers we spoke with, tend to be smaller and lighter than the supercharger that would be necessary to make the same power. And the exhaust heat extracted by the turbine eases the thermal load on the catalytic converters. Meanwhile, the supercharger is a constant parasitic drag on the power and efficiency of an engine, even when it's not making boost. And while superchargers have made strides in efficiency, as one engineer told us, "If one of your key program goals is to maximize fuel economy, you're going to lean toward a turbocharger."



So why does anyone use a supercharger? Joe Folk, assistant chief engineer for General Motors' V-8s and former engineering group manager for all super- and turbocharging within GM, says that "it comes down to the character you're trying to achieve." Chris Cowlands, director of FCA's advanced and SRT powertrain engineering, agrees, saying that when SRT engineers started developing the Hellcat engine, "making the power we were looking for was actually going to be easier with a turbocharged engine." But three major factors, "sight, sound, and feel," pushed them toward a supercharger. Even so, he sees a limited future for the supercharger. "I think we're going to see the electric supercharger come in to replace the mechanically driven one," he says. At which point, this whole fight can start all over again.