achatesPOWER

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Achates' engine demonstrated up-to 20% efficiency improvement v. today's diesel engines while meeting 2027 ultra-low NOx emission standards

Achates Power to showcase most economically viable 'forever engine' architecture at ACT Expo, with ability to operate on diesel, renewable diesel, and hydrogen fuels with lowest total cost of operation for fleets

May 20th 2024, Las Vegas, NV **Achates Power, Inc. (API)** will display one of three engine variants of what has been demonstrated as the cleanest and most efficient combustion engine architecture to date. With the industry facing massive disruption due to stringent limits on both criteria and CO2 emissions, API's demonstrations have proven this architecture can satisfy regulatory requirements without detriment to the fleets or ultimately the economy.

"In pursuit of clean technology for today's on-road and off-road industries, it's critical to place priority on end user customers such as fleets and operators. Technology-forcing regulations with a backdrop of uncertainty on things like infrastructure, cost, and fundamental capability to 'do the job' make it difficult for the operators to navigate this energy transition." said Dave Crompton, President & CEO of Achates Power.

"For the first time ever, an internal combustion architecture has been simultaneously proven to reduce NOx, beat the most stringent regulations proposed with margin to spare, and improve real world fuel economy by as much as 20%, all while demonstrating robust extended life compliance. Where it matters most for fleets and ultimately our economy is that this technology is able to achieve these advantages with lower cost and complexity, no reliance whatsoever on capital investment for fueling, or dependence on infrastructure development by the energy providers."

Demonstrated Capability - API has demonstrated the capability of this technology in rigorous real-world applications, production defense applications, tens of thousands of test cell hours, and in the emissions lab. "We've taken this well beyond 'concept phase' in the past several years through extensive testing, creation of a combat variant now being produced for the U.S. military, and heavy-duty commercial fleet on-road testing." said Dnyanesh Sapkal, Executive Vice President, Engineering & Operations. "We've even been able to demonstrate that our opposed-piston architecture is capable of using the aftertreatment systems of today to meet tomorrow's ultra-low NOx emissions standards with robust compliance through the 800,000 mile useful life requirements. Our accomplishments in low-load, idle, and off-cycle emissions position this to be the best combustion technology in the industry."

Clean On-Road Efficiency - Where API sees an immediate opportunity for early adoption of the opposed-piston technology over today's best-in-class engines is commercial trucking where emissions standards are quickly becoming much more stringent to a point where aftertreatment systems' cost and complexity may drive truck costs higher and reliability lower - with a penalty to fuel economy. In a joint demonstration with CALSTART and Walmart, an API 10.6 liter engine was retrofitted into a production class 8 truck. During the demonstration period in California, the truck achieved up to 10.8 mpg on a 389 mile delivery route with an average of 10% better fuel economy compared to a best-in-class production engine, over a variety of routes with the advantage increasing to 22% on some routes. This was done within the proposed 2027 ultra-low NOx emissions standard and with only an off-the-shelf current

production one-box aftertreatment system (no additional thermal management or emissions control devices were required).

Alternative Fuel Advantages - The inherent combustion efficiencies of the API engine design not only allow for a cleaner utilization of today's diesel, but also an easier transition to multiple fuel types available today and tomorrow.

In February of 2024 at the Argonne National Laboratory, the U.S. Department of Energy successfully demonstrated an Achates test engine running on hydrogen combustion without the aid of a spark or dual-fuel pilot ignition. Early testing has proven that the simplicity of this engine design enables an easier transition to hydrogen combustion over 4-stroke engine concepts because of the base engine design, diesel-like efficiencies, and indications of potential power density.

In a joint demonstration with Neste, the world's leading renewable diesel producer, the already proven 10% greenhouse gas emissions (GHG) reduction advantage of the OP engine technology was amplified when using Neste MY Renewable Diesel™. This is a drop-in hydrotreated vegetable oil (HVO, R99) that requires no engine calibration changes and is available today across multiple states. The API engine running Neste's renewable fuel resulted in a consistent 4-5% GHG emissions reduction compared to fossil diesel across all test cycles as well as lower criteria emissions. Atop of the 75% lower net GHG advantage Neste MY Renewable Diesel has over fossil diesel's lifecycle, this is the lowest GHG level that API has ever measured.

"Our testing with Neste's renewable diesel represents an important step towards sustainable on-road and off-road operations because the engine can operate efficiently and reliably on a range of fuels, including lower carbon and zero carbon fuels. We have never measured lower greenhouse gas than when running on the Neste MY Renewable Diesel," Sapkal continued.

Base Engine Technology Overview - The light-duty 2.5 liter engine displayed at ACT Expo represents all three displacement variants undergoing testing and validation work - with the smallest having been demonstrated in a class 2a pickup. Not shown are the 5 liter and 10 liter engines which, due to their superior power density, have ratings comparable to today's medium and heavy duty engines in the 7 to 15 liter space.

Benefits of the API opposed-piston engines include lower heat rejection, higher power density, and fewer moving parts for better reliability and increased fuel efficiency. With this configuration, every stroke is a power stroke which translates to optimal thermal efficiency. Where this matters to the fleets is 2027 and beyond emissions regulations where combustion efficiencies and thermal management are critical for aftertreatment cost, simplicity and functionality. Conversely, the Engine Manufacture Association estimates that total engine and aftertreatment system level pricing of 4-stroke engines could increase as much as $31,000 per truck to meet 2027 emissions standards.

Manufacturing Readiness - The true differentiator for trucking fleets when compared to other technologies, is that API is doing so without the use of exotic materials, non-conventional manufacturing, or complex aftertreatment systems - making it a 'now' solution.

"The right technology matters and right now, this is the right technology. One of the most compelling things about this technology is that it can be put into practical use with superior fuel efficiency and without the added complexity, cost and reliability concerns associated with stretching conventional engines and their emission aftertreatment systems to meet the future low NOx and CO2 limits, and without the need for a fleet to redesign its routes around shorter-range vehicles and sparse refueling/recharging infrastructure." said Dr. John Wall, Board of Directors, API and former Cummins Chief Technical Officer. Dr. Wall also serves as an advisor to the International Council of Clean Transportation, Activate in Berkley and Boston, as well as several other active roles in clean transportation technology. He continued "For fleets that ultimately want to reach zero emissions, including renewable diesel and hydrogen, the Achates technology is a good match."

Engine manufacturing plants today can easily produce this engine through sustainable assembly practices and with approximately 300 fewer parts compared to today's 4-stroke engine. The familiarity of the materials used in

production also means that the supply chain of today can efficiently support the manufacturing of this engine architecture without sourcing disruptions and constraints.

OEM integration for this solution can be easily done into today's chassis, with today's transmissions, while benefiting from a reduction in cooling package size requirements.

Combat Durability - In 2021, engine manufacturer Cummins, Inc. was awarded an $87m contract from the U.S. Army to manufacture an opposed-piston 14-liter engine in partnership with API. who Cummins recognized as the expert in advanced opposed piston technology. As a combat engine, this engine faces some of the harshest duty cycles imaginable. The unmatched power density, heat rejection advantage, and capability to burn a variety of fuels (JP8, F24, diesel) made this the technology of choice for the combat application needs.

Achates Power, Inc

For 20 years, Achates Power has been researching and enabling technology for best-in-class combustion engines, providing economic value to its customers, and accelerating positive impact on the environment through obtainable technologies. Achates Power works with the leading engine manufacturers to license designs, provide development and testing tools, build software, and obtain engine patents for a range of applications that reduce CO2 and criteria emissions and provide robust compliance in a cost-effective manner.

Headquartered in San Diego, California, Achates Power is led by some of the most experienced technical and commercial leaders in the commercial powertrain industry and financially backed by investors and industry partners including Climate Investment, Department of Energy, Department of Defense, California Air Resources Board, and ARPA-E.