# GM HCCI engine can operate at idle

Posted Jun 26th 2008 at 3:02PM by **Sam Abuelsamid**

Filed under: **GM**, **HCCI**


General Motors first showed off its prototype Homogeneous Charge Compression Ignition (HCCI) engines last summer in an Opel Vectra and a Saturn Aura. **We had the opportunity to drive these vehicles at GM's Milford Proving Ground at a very early stage of development.** Because HCCI only works at part throttle conditions (while engines in cars have to work under all conditions), these new power plants have the ability to switch modes on the fly between HCCI and spark ignition. When we drove the cars, the HCCI only operated when driving at up to 55mph. At higher speeds or loads or when idling, the engine was in normal spark ignition mode.

GM's researchers continued developing the HCCI engine over the intervening 10 months and it is now able to operate in HCCI mode at idle as well. They demonstrated the HCCI Aura to journalists in California earlier this week and, according to Mike Levine of PickupTrucks.com, it's making good progress. The basic hardware to make HCCI work exists with direct injection, variable valve timing and pressure and temperature sensors in the combustion chamber. The key now is to develop the control algorithms to manage the sparkless combustion. The beauty of HCCI is the potential to improve fuel consumption to almost diesel levels without the expensive aftertreatment systems. HCCI engines can also operate on conventional gasoline or even ethanol.

[Source: General Motors]

***Press Release***:

***GM DEMONSTRATES FUEL-SAVING ENGINE TECHNOLOGY BREAKTHROUGH WITH HCCI-ENABLED***

***SATURN AURA CONCEPT***

*LOS ANGELES – General Motors demonstrated its progress on developing a future advanced engine technology for consumers that squeezes more miles per gallon of gas and reduces emissions. GM engineers have brought the advanced combustion technology from the laboratory to the test track and, now, to the highway in a driveable concept vehicle – a Saturn Aura sedan equipped with homogenous charge compression ignition (HCCI).*

*GM demonstrated its latest progress with the HCCI technology during a media test-drive program in the Los Angeles area. Journalists drove the HCCI-enabled Aura concept on public roads to get a real-world feel for the efficient and low-emissions engine. HCCI provides up to a 15-percent fuel savings when combined with several additional advanced technologies, while meeting current emissions standards. GM has previously demonstrated the HCCI-equipped Aura in New York and Washington, D.C. The Saturn Aura concept vehicle is capable of operating in HCCI mode during idle, in addition to highway driving. The HCCI operation at idle represents a significant technological advance that GM engineers believe could be the first for the industry. The breakthrough enables a wider range of HCCI operation, extending the efficiency-enhancing benefit of the technology.*

*The Saturn Aura prototype operates on HCCI at idle, and up to approximately 55 mph, transitioning to spark ignition at higher vehicle speeds and during heavy engine load. An extended range for HCCI operation is intended as further refinements to the control system and engine hardware are made. "By achieving HCCI operation at idle, we have eliminated a significant hurdle in our development of this very important fuel-saving technology," said Tom Stephens, executive vice president, GM Global Powertrain and Global Quality. "We are beginning to see how we can make this technology a real benefit for consumers. By combining HCCI with other advanced gasoline engine and control technologies, we can deliver a good fuel savings value for consumers."*

*How HCCI works*

*HCCI, along with other enabling advanced technologies, approaches the engine efficiency benefit of a diesel, but without the need for expensive lean NOx after-treatment systems. Its efficiency comes from reduced pumping losses, burning fuel faster at lower temperatures and reducing the heat energy lost during the combustion process. Consequently, less carbon dioxide is released because the vehicle's operation in HCCI mode is more efficient.*

*Highlights of the technology include: • Engine efficiency approaching the benefit of a diesel with substantially reduced after-treatment cost • Builds off proven gasoline direct-injection and variable valve actuation technologies • Adaptable to conventional gasoline engine architectures • Requires only conventional automotive exhaust after-treatment • Compatible with all commercially available gasoline and E85 ethanol fuels.*

*An HCCI engine ignites a mixture of fuel and air by compressing it in the cylinder. Unlike a spark igni- tion gas engine or diesel engine, HCCI produces a low-temperature, flameless release of energy throughout the entire combustion chamber. All of the fuel in the chamber is burned simultaneously. This produces power similar to today's conventional gas engines, but uses less fuel to do it.*

*Heat is a necessary enabler for the HCCI process, so a traditional spark ignition is used when the engine is started cold to generate heat within the cylinders and quickly heat up the exhaust catalyst and enable HCCI operation. During HCCI mode, the mixture's dilution is comparatively lean, meaning there is a larger percentage of air in the mixture. This reduces the throttle losses of a conventional spark-ignited engine at low loads, helping the HCCI engine approach the efficiency of a diesel, but requiring only a conventional automotive exhaust after-treatment. Diesel engines require more elaborate and more expensive after- treatment to reduce emissions.*

*HCCI builds on the integration of other advanced engine technologies – some of which are already in production and can be adapted to existing gas engines. The cylinder compression ratio is similar to a conventional direct-*

*injected gas engine and is compatible with all commercially available gasoline and E85 fuels.*

*"I am pleased with our engineering team's progress," said Stephens. "It is another initiative in GM's advanced propulsion technology strategy to lessen our dependence on oil. HCCI, direct injection, variable valve timing and lift, and Active Fuel Management all help improve the fuel economy and performance of our internal combustion engines. I am confident that HCCI will have a place within our portfolio of future fuel-saving technologies."*

*Achieving HCCI operation at idle has long been a challenge for HCCI engineers, because the relatively low-temperature and light engine load characteristics generally inhibit the proper thermodynamic conditions for successful, controllable autoignition. Also, heat is needed at start-up and idle to light-off the catalytic converter.*

*GM's engineers overcame these challenges with advanced control of the direct injection system and a HCCI-specific cylinder pressure sensor system. After spark ignition is used to start the engine, the engine's sophisticated control system manipulates the combustion process via input from the cylinder pressure sensors so that auto-ignition can occur during idle.*

*"Fuel consumption with a spark ignition engine is relatively high when idling, so this new development in our HCCI process helps to enhance fuel efficiency," said Dr. Matthias Alt, HCCI program manager, GM Powertrain.*

*GM's HCCI strategy and the Saturn Aura concept*

*The emerging HCCI technology offers several paths for implementation in a production vehicle. GM's strategy combines the efficiency enhancements of HCCI and the power-on-demand attributes of spark ignition. This combination delivers enhanced fuel savings over a comparable, non-HCCI engine, but with the performance consumers have come to expect during higher engine load situations, such as passing or entering a freeway.*

*"GM's HCCI development focuses the technology where it will deliver the most benefit at the most reasonable cost for the consumer," said Alt. "An HCCI engine that uses HCCI in the entire operating mode would be heavier, noisier, more costly and would not deliver the performance experience people expect from a modern car."*

*With GM's technology, proven gasoline engine technology is retained and the engine has spark plugs and a conventional ignition system. The vehicle operates in HCCI mode up to about 55 mph (88 km/h) and switches to spark-ignition for higher-speed, higher-load conditions. It also engages spark ignition mode for passing at lower speeds and other higher-load demands.*

*The Aura concept is powered by a 2.2-liter Ecotec engine that makes 180 horsepower (134 kW) and 170 lb.-ft of torque (230 Nm). It features a central direct-injection system, with variable valve lift on both the intake and exhaust sides, dual electric camshaft phasers and individual cylinder pressure transducers to control the combustion as well as deliver a smooth transition between combustion modes. A sophisticated controller, using cylinder pressure sensors and GM-developed control algorithms, manages the HCCI combustion process, as well as the transition between HCCI combustion and conventional spark-ignition combustion.*

*Challenges for production*

*The biggest challenge of HCCI is controlling the combustion process. With spark ignition, the timing of the combustion can be easily adjusted by the powertrain control module, with control of the spark event. That is not possible with HCCI's flameless combustion.*

*The mixture composition and temperature must be changed in a complex and timely manner to achieve comparable performance of spark-ignition engines in the wide range of operating conditions. That includes extreme temperatures – both hot and cold – as well as the thin-air effect of high-altitude driving. Advancements* *such as idle operation and improved noise, vibration and harshness bring HCCI technology one step closer to production. GM's global HCCI team will continue to refine the technology in the wide range of driving conditions experienced around the globe.*

*"Our development costs for HCCI are very expensive; however, we have made tremendous strides in bringing this much awaited combustion technology out of the lab and onto the test track with the Saturn Aura concept vehicle," said Prof. Dr. Uwe Grebe, executive director for GM Powertrain Advanced Engineering. "More research and testing are required to ensure the technology is ready for the great variety of driving conditions that customers experience."*