Engineering

Developing a next-generation power source for future mobilities

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The author behind the wheel of the Chiba University students' formula car, a project on which the author is advising

Background of Research

The exhaust gas from gasoline engines in today's modern passenger cars contains lower levels of pollutants, such as carbon monoxide and nitrogen oxides (but excluding carbon dioxide (CO_2), which contributes to global warming), than can be found in the air in large cities, meaning that cars have in effect become atmospheric cleaning devices.

In order to achieve reductions in car engine CO_2 emissions, and in the face of finite fossil oil reserves, the goal has been set to raise the thermal efficiency of gasoline engines from their current maximum of around 30% by half again to around 45%. It will therefore be essential to build a better engine, and rather than just building on existing engine technology, that goal will require innovation involving non-conventional technology. Working together with car companies and other partners, the team in my research laboratory is engaged in research and development on HCCI combustion technology. (HCCI stands for Homogeneous-Charge Compression Ignition, a new combustion method that has recently been attracting attention.)

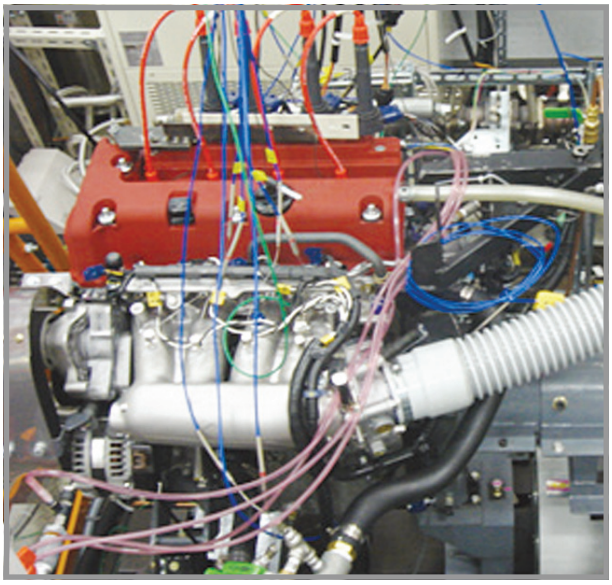
Results from this research

The biggest problem to date with producing a commercial HCCI engine was that past prototypes could only be used with a throttle opening angle of between 20% and 40%. This meant that when pressing down hard on the accelerator in order to accelerate or drive up a hill, the engine would be switched to conventional combustion, resulting in poor fuel consumption performance. Our team has succeeded in expanding the range of throttle opening angles where an HCCI engine can operate to between 0% and 60%. No ignition plug is required for an HCCI engine, so combustion is initiated by re-breathing hot exhaust gas from the previous cycle during the compression stroke. Taking advantage of the effect of interference with another cylinder, air and exhaust gas are drawn in by the force of a pressure greater than atmospheric pressure. In order to avoid any explosive combustion, we developed a system to control the temperature distribution inside the cylinder (Fig.1), and also are conducting experiments using a prototype engine (Fig.2). With HCCI engines, thermal efficiency improvements of around 15% - 35% can be achieved compared to a conventional engine. Industries-academia collaboration on research and development is currently underway with the goal of producing a commercial version of this engine soon.

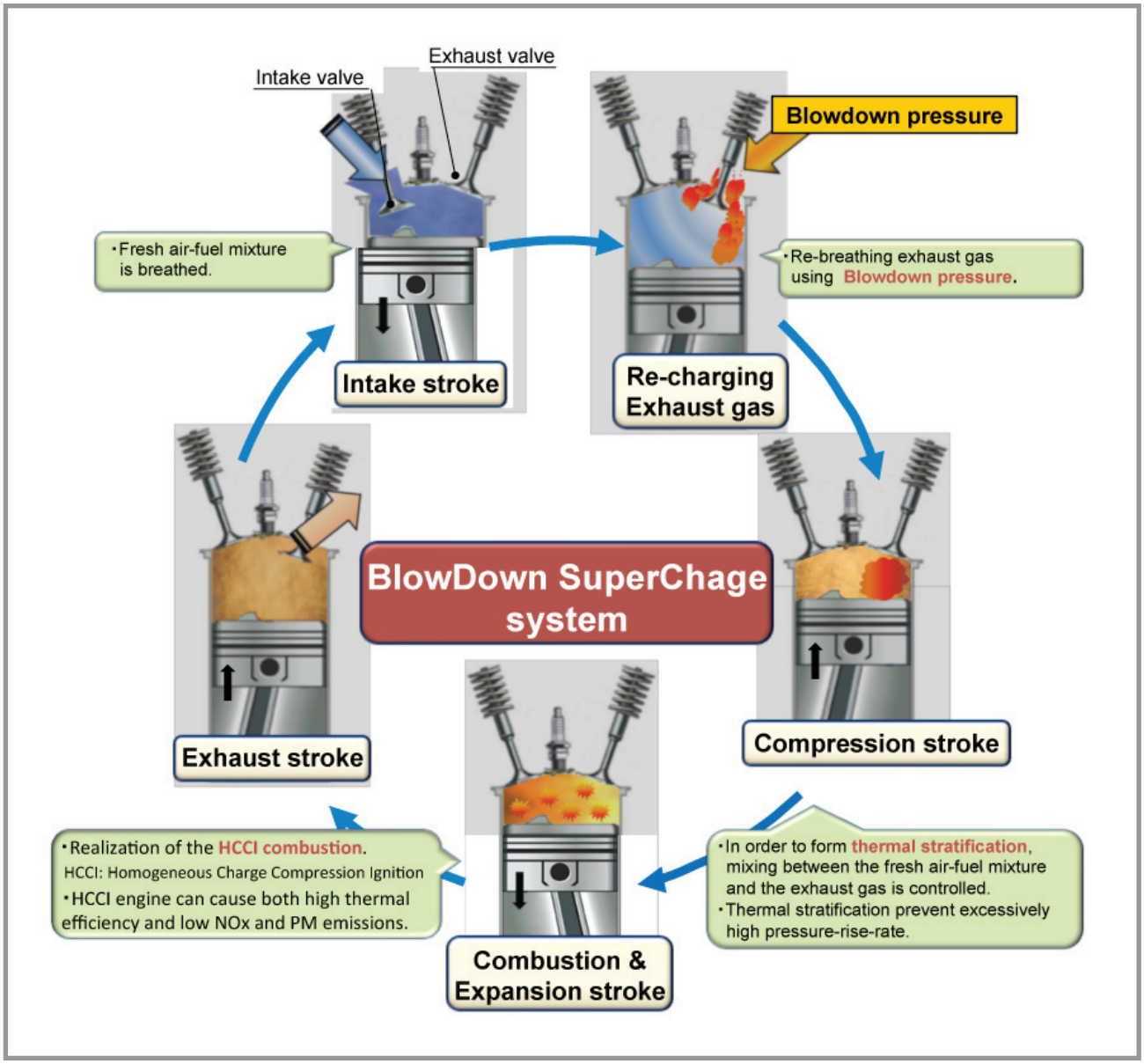
Prospective developments

Much remains undiscovered in the research of engines, an area of study with a long to-do list. Some people may think it would be better to just make the leap straight over to electric cars now. However the energy density of electric car batteries is less than one-hundredth that of gasoline, electric cars are

heavy, and they will also be expensive. There is likely to be an increase in the number of hybrid cars, which combine a gasoline engine with an electric motor, and while it's thought there will also be an increase in the number of "plug-in hybrid" cars whose batteries can be recharged at home overnight, those cars will demand the development of optimal engines, motor and other power electronic components and control systems, and moreover such cars will have to become much more affordable. To that end, engineers from a wide range of disciplines will need to work together and exchange ideas, and we at Chiba University extend that invitation to our fellow researchers.



▲ **Fig.2 : The HCCI engine in development**



▲ **Fig.1 : How an HCCI engine works**