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The Electrification of the Powertrain at Honda, an approach towards sustainable mobility

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Abstract

Honda's approach towards sustainable mobility is described by wide spreading the Honda Integrated Motor Assist System, a hybrid powertrain system applied to not only the most recent models at Honda such as the new Insight and CR-Z but since more than 10 years to all our hybrid vehicles and further by showcasing the FCX Clarity Fuel Cell Electric Vehicle innovation including degradation analysis and innovative V-flow stack structure as well as infrastructure research such as solar powered hydrogen station and cogeneration unit.

1 Introduction

Ladies and Gentlemen,

Honda's vision for personal mobility for the next 100 years of mobility calls for an accelerated shift away from fossil fuels, and for the early development of technologies that will reduce greenhouse gas emissions to zero. This is because continuing growth in the world's population is likely to result in continuing growth in the demand for mobility.

Honda's vision for the sustainable mobility society of the future is based on the concept of mobility that uses energy generated by Honda technology. However, this will not be an easy goal to achieve. We will need to overcome challenges far greater than anything we have experienced in the past. Honda is determined to meet these challenges and realize this vision by accelerating initiatives in response to environmental problems.

In the Energy Technology Perspective Report 2008 of the International Energy Agency, the generated Blue Map scenario targets at reducing global CO₂ emissions to half the 2005 level by 2050. This means that Blue Map emissions will have to be at least one forth the baseline emissions of 62 Gt in 2050.

In order to reduce total CO₂ emissions to half of the current level by the end of the forecast period until 2050, the society must work as a whole. For example, by widespread expansion of low or zero carbon fuels or electric power as well as highly efficient transportation using multiple energy carriers.

The transport sector will be forced to make tremendous efforts to reduce CO₂ emissions to a level of 12.5 Gt by 2050. This scenario could be realized only when we improve the internal combustion engines, promote electrification technologies such as hybrid and EV, and widely adopt bio-fuel and hydrogen fuel cell electric vehicles.

In addition to continuous efficiency improvement of internal combustion engines, hybridization has just entered the phase of engineering improvement targeting wide use.

Research is being accelerated for further electrification including plug-ins.

Research is also conducted for battery electric vehicles and range extender electric vehicles.

However, there still are technical challenges such as energy density. These challenges cannot be managed by engineering efforts alone, but also science.

Fuel cell vehicles still have issues such as durability and cost which need to be overcome and in the latter to be dramatically reduced.

Internal combustion engines must be continuously improved for efficiency. Research of highly efficient engines such as HCCI are progressively carried out considering the recent move toward the use of biofuels and synthetic fuels.

Gasoline and diesel engines are moving towards downsizing and HCCI, PCCI for further efficiency improvement.

Efforts are being made targeting both high efficiency and affordability.

Taking advantage of various fuels including biofuels, working together with the fuel production side may lead to a totally new concept of technology with best matching of fuel and engine for optimum efficiency.

2 Hybrid Technology Evolution

Honda original Insight was the first introduction of hybrid car in the world in 1999. Now launching our 6th all-new hybrid vehicle, Honda has a long experience to fully understand customers' wants and needs when it comes to hybrid technology.

Honda was the first to have 3 hybrids vehicles available and the all-new CR-Z is the latest symbol of our commitment and what's to come – a portfolio of hybrids intended to serve different needs and tastes of consumers.

The CR-Z will be joined soon by a small hybrid car based on the Jazz in Europe.

With the Civic Hybrid, the new Insight, and the CR-Z, we expect to grow Honda's European hybrid sales to several times their current level further advancing the fuel efficiency leadership of the Honda brand.

Honda has a clear and defined hybrid story for the next 5 years.

The inspiration behind the CR-Z was to create a new type of car that offers a sporty driving experience, combined with the environmental responsibility of a petrol electric powertrain, wrapped in an aerodynamic coupe body.

The overall power output of the engine and IMA system is 91 kW at 6100 rpm combined with a healthy 174 Nm of torque at just 1,500 rpm. The peak torque figure is identical to that of the 1.8-litre Civic and arrives at just 1,500 rpm, a level where previously only turbocharged engines deliver their maximum.

Even with torque levels directly comparable with a Civic, the CR-Z emits 35 g/km less CO₂. Other harmful exhaust emissions are also very low and the Nickel Metal Hydride battery pack can be recycled through Honda dealers, at the end of the vehicle's life.

3 FCX Clarity Innovative Technology

Let us elaborate how various forms of powerplant electrification help decrease CO₂ emissions.

Firstly, the internal combustion and hybrid vehicles both offer a very long driving range. They also offer quick refuelling capability.

Then, depending on the system configuration, the plug-in hybrid vehicle can offer zero CO₂ emissions when driven on electric power alone but only for a limited driving range.

Thirdly there are the Battery Electric Vehicles. Although they emit no CO₂ emissions, they are limited by their short range. To extend their range, there are now many ideas being considered, from quick charging to battery swap.

And finally we have fuel cell electric vehicles.

As you may already be aware, hydrogen fuel cell vehicles combine a long driving range with significant reduction in CO₂ emissions.

With the development of the required hydrogen station infrastructure, mobility as we know it today can become fully sustainable.

Honda's research on fuel cells goes back to the late 1980's.

In December 2002, in what was a world first, Honda started leasing the FCX.

This FCX incorporated many already well-established Honda automobile technologies such as:

- Advanced motor technology from the Honda EV PLUS electric vehicle which was introduced in 1996 much earlier than currently in the electric vehicle hype.
- High-pressure tank technology from the Civic GX natural gas-powered vehicle.
- Energy management technology from the first generation Honda Hybrid Insight and other hybrid vehicles which have followed.

The heart of the powerplant is the fuel cell stack and its evolution over time.

- First came a material evolution from 1999 to 2003, with switching from fluorine to aromatic electrolytic membrane material for a wider operating temperature range.
- At the same time, we switched from carbon-based to metal-based separators to prepare for future mass production.

The fuel cell stack evolved again in 2006 with the adoption of a new design structure.

In this latest evolution, it has a 'V Flow' cell structure featuring 'Wave Flow Channel' separators. The result is a lighter, more compact, 1-box stack construction.

These are the key factors and related countermeasures for occurring stack degradation.

Through almost endless efforts to analyze and improve the degradation we have accomplished a big improvement of the Fuel Cell stack which is applied to current Honda FCX Clarity.

We will continuously improve not only the performance of the fuel cell stack but also our capability of the detail analysis for the key area such as degradation and others.

4 Hydrogen Infrastructure Research

In January 2010, Honda began trials of a next-generation solar hydrogen station, which will produce hydrogen from water using electric power produced by solar cells. The station's solar panels are based on original Honda technology, and could potentially be used in household hydrogen supply systems in combination with a new hydrogen production system that dramatically reduces power consumption during hydrogen production and storage.

The latest generation of a PV-Electrolyzer-Hydrogen station is designed to supply high pressure hydrogen without using a compressor. Designed as a single, integrated unit to fit in

the user's garage, Honda's next generation Solar Hydrogen Station is reduced in system size, while producing enough hydrogen (0.5kg) via an 8-hour overnight fill for daily commuting (10,000 miles per year) for a fuel cell electric vehicle.

The previous Honda Solar Hydrogen Station system required both an electrolyzer and a separate compressor unit to create high pressure hydrogen. The compressor was the largest and most expensive component and reduced system efficiency. By creating a new high differential pressure electrolyzer, our Honda engineers were able to eliminate the compressor entirely. This innovation also reduces the size of other key components to make the new station the world's most compact system, while improving system efficiency by more than 25% (value calculated based on simulations) compared to the solar hydrogen station system it replaces.

Compatible with a "Smart Grid" energy system, the Honda Solar Hydrogen Station would enable users to refill their vehicle overnight without the requirement of hydrogen storage, which would lower CO₂ emissions by using less expensive off-peak electrical power. During daytime peak power times, the Solar Hydrogen Station can export renewable electricity to the grid, providing a cost benefit to the customer, while remaining energy and thus CO₂ neutral.

Besides that, research in Natural Gas based reformer systems to produce hydrogen in a very efficient manner has been conducted including combined heat and electric power supply. Home Energy Station IV, is the 4th generation prototype model and was operated to verify both hydrogen supply to FCX and power generation that can be interconnected with the commercial power grid.

Verification tests demonstrated that this is a new energy supply system format that can simultaneously reduce the environmental by significantly lowering CO₂ emissions load while providing merits to the user by reducing total energy cost.

5 Summary

To reduce CO₂ emissions from automobiles, internal combustion engines such as gasoline and diesel engines are being made more efficient but there are limitations to such efforts.

Accordingly along with the improvement of engine efficiency, technical efforts are directed towards developing electric drive vehicles such as hybrid, EV and Fuel Cell Electric Vehicles.

Considering the Fuel Cell Electric Vehicle being the ultimate car, Honda has been continuing research and development to prepare this vehicle for widespread use.

Fuel Cell Electric Vehicle performance has been improving steadily to date, but there still is a hurdle we have to clear before its commercialization. That is, FCEVs must realize cost, durability and reliability comparable to gasoline-fueled vehicles.

As explained for cost-related issues, we must also refine a wide variety of related element parts, moving a step higher each time.

Regarding durability and reliability, real-world feedback is vital, in addition to quality assurance technology in production. We will make step-by-step efforts to tackle this challenge as well.

Recently we have conducted long run test of FCX Clarity in Japan from Utsunomiya where our Automotive R&D center is located to Aichi prefecture without recharge of hydrogen fuel thorough the range of more than 510 km.

Refueling time is around 3 to 4 minutes which is relatively practical time compared to conventional ICE engines.

Honda is working hard developing FCEVs that can be put to widespread use.

In Japan there started the FCCJ which stands for Fuel Cell Commercialization Conference of Japan and investigates the commercialization scenario and hydrogen stands towards 2015 deployment of the FCEV to the Japanese market.

Honda has been striving to keep blue sky for children and tackle environmental issues since CVCC engine was invented from more than 30 years ago.

We will make more efforts to approach towards sustainable society and create innovative technology further for our society and customer.

Thank you.