

Development of an Electric Drive Motor for the Honda FCX Clarity

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Abstract :

A new type of DC brushless motor was developed as the drive motor for a fuel cell electric vehicle, the Honda FCX Clarity. A more compacted design was achieved by integrating a power drive unit in addition to using a gearbox with a coaxial structure. The magnetic circuit was also optimized by implementing an IPM rotor to gain higher rotation speed to improve maximum speed as well as higher output to improve engine performance. The drive unit reduced the length by 162 mm and the height by 240 mm through the innovations above when compared to conventional models. Furthermore, the drive motor performance reached a maximum output of 100 kW and a maximum torque of 256 Nm.

This motor has contributed to expanding cockpit space and increasing drive performance and cruising distance above conventional 2.4 liter gasoline vehicles.

Development of an Electric Drive Motor for the Honda FCX Clarity

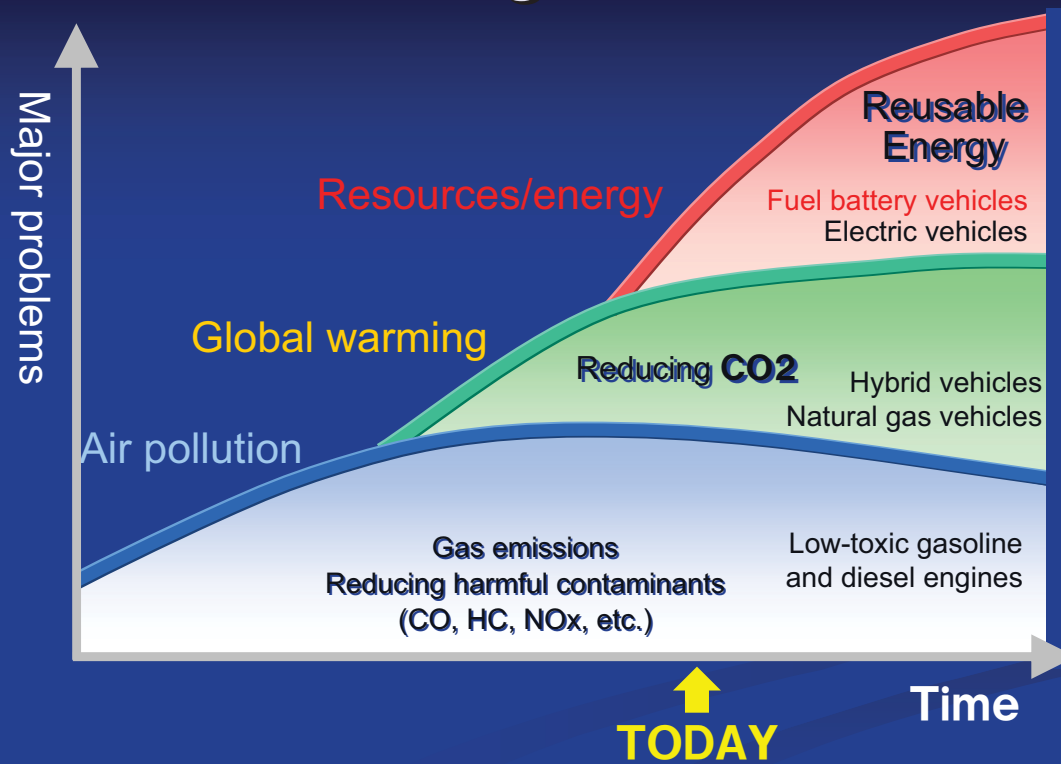
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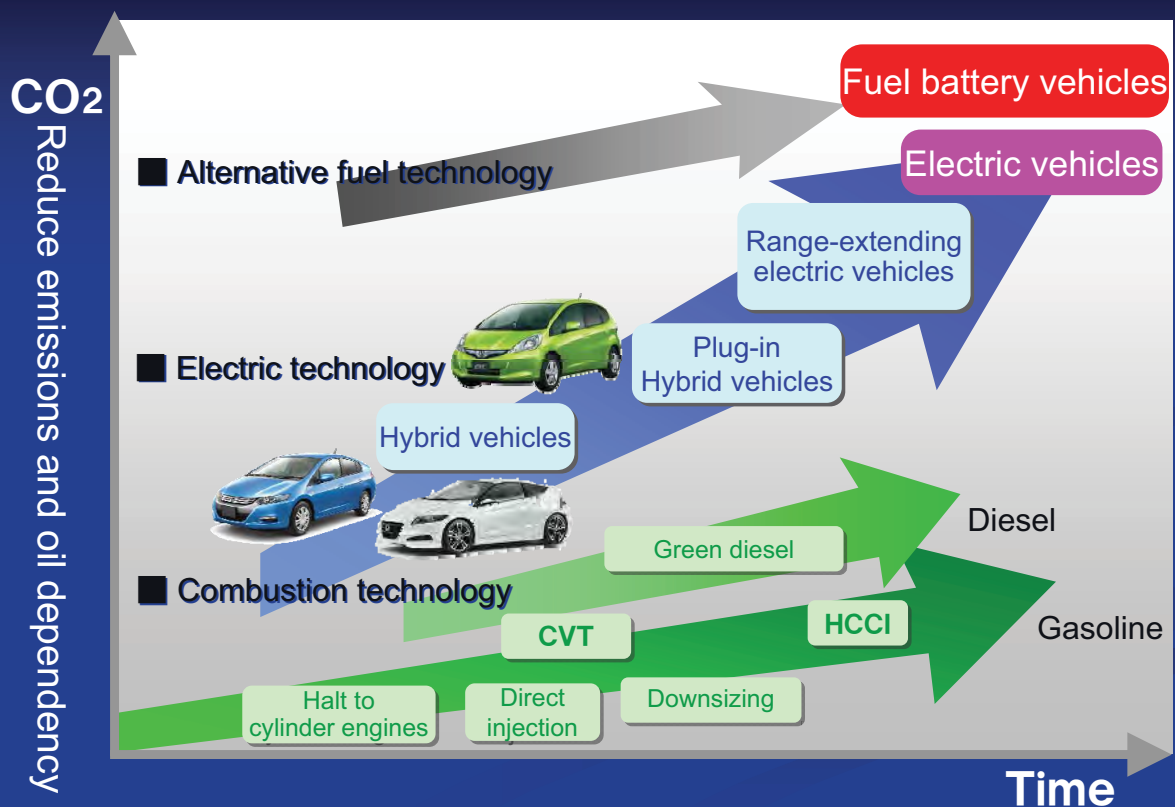
Contents

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Background



Road Map for Next Generation Vehicles



Fuel Battery Vehicle Development

Efforts toward countermeasures
for environmental problems

Develop FCV with a
zero emissions peak



2003 model
FCX

Max Power 60kW
Max Speed 150km/h



2005 model
FCX

Max Power 80kW
Max Speed 150km/h



Drivable in cold
climates



2009 model

FCX
CLARITY

Timing drive performance,
package, and styling

1997

EV
PLUS

Max Power 49kW
Max Speed 130km/h

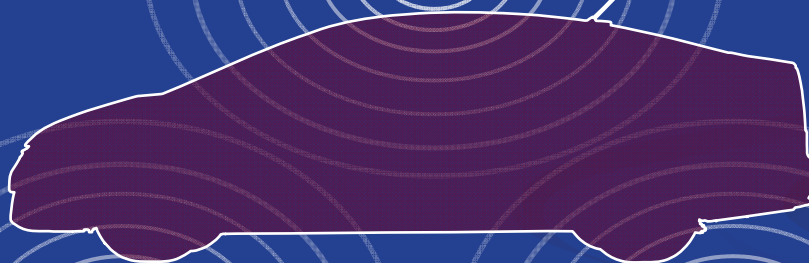


First commercial fuel
battery vehicle in the world

Development Concept

Eye Catching Design

A creative design inspiring a
futuristic look.



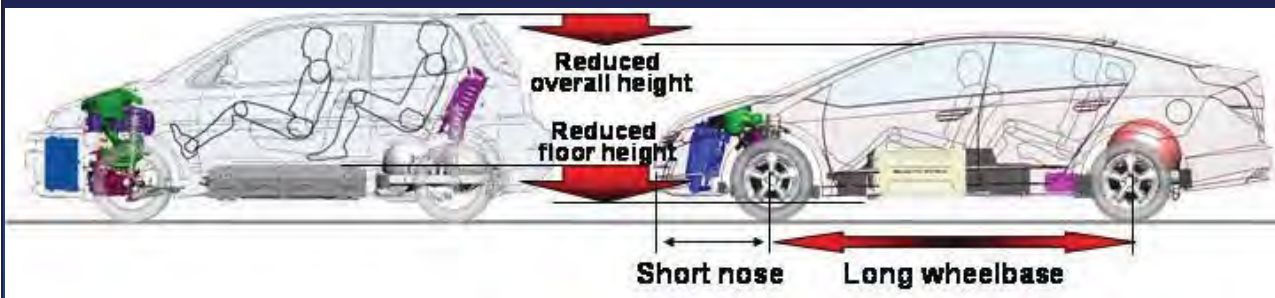
Innovative Human Package

A revolutionary platform using the
layout freedom of fuel-battery vehicles

Grand driving experience

A motor drive that can continue
increasing distance of drive directly

Objective of Development



2005M FCX

Max Power 80kW
Max Speed 150km/h

FCX Clarity

Max Power 100kW
Max Speed 160km/h

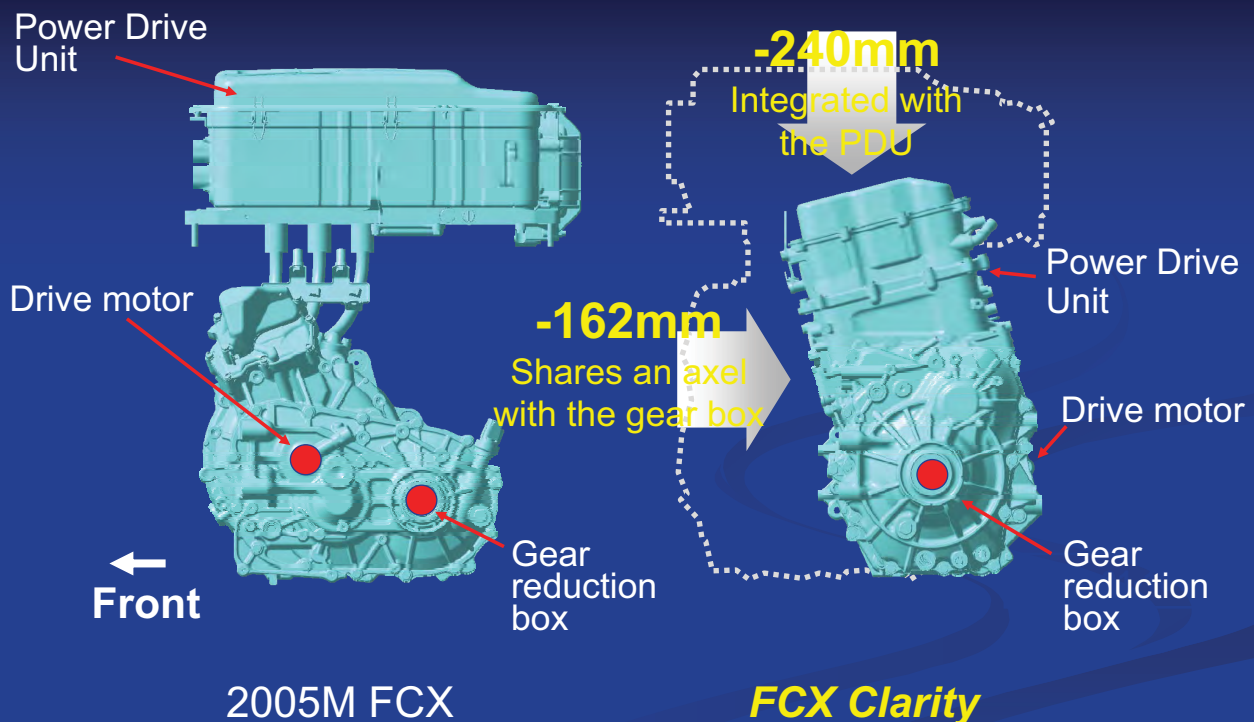
1. Miniaturized drive unit

- Height/ length of drive unit:
For the 2005MFCX
-240mm/-160mm

2. Higher output and rotation

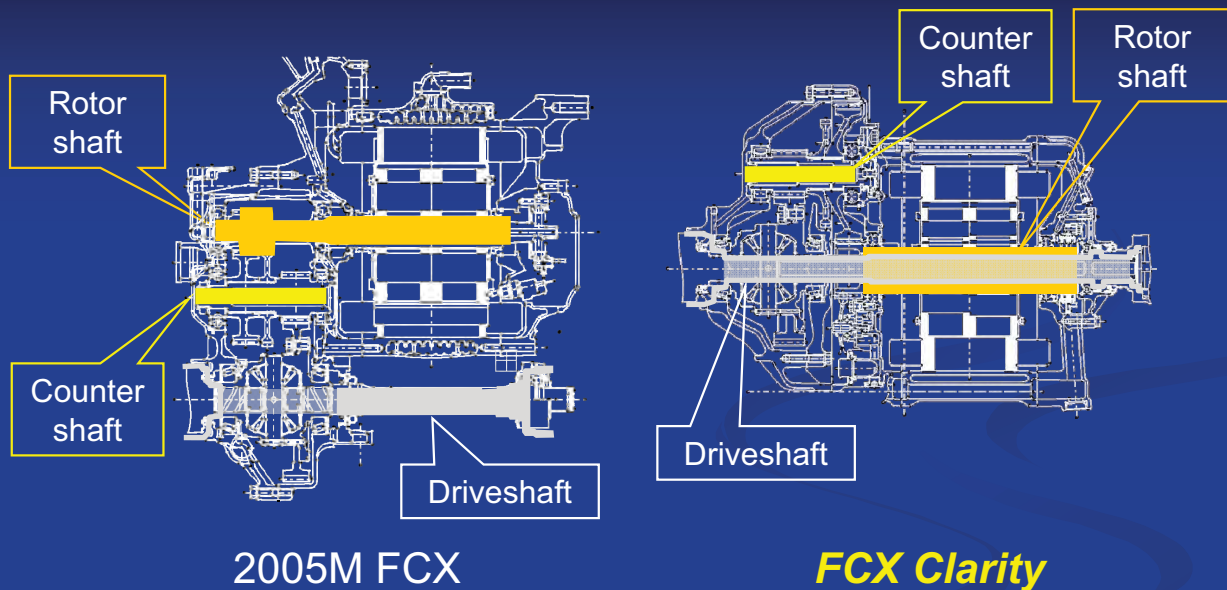
- Max output/Max torque:
100kW / 256Nm
- Max rotation speed: 12500 min⁻¹

Miniaturized Drive Unit



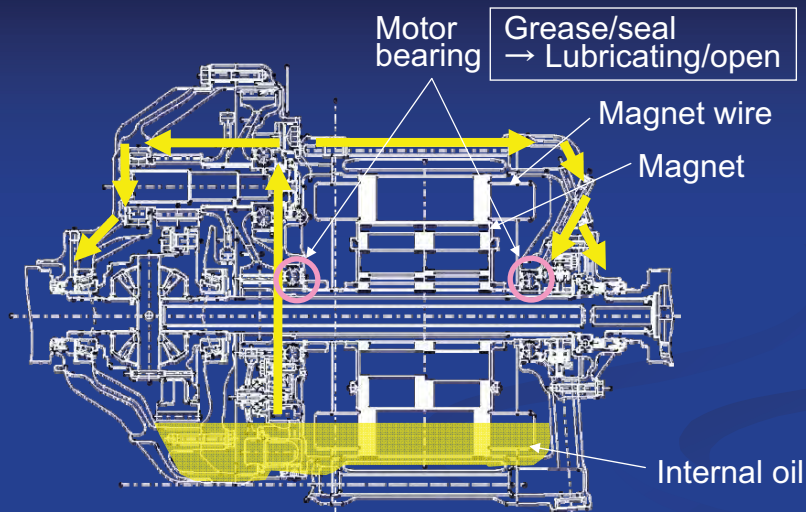
Miniaturized by integrating the motor, gear box, and PDU.

Co-axial motor and gear box



Miniaturized using a co-axial motor and gear box.

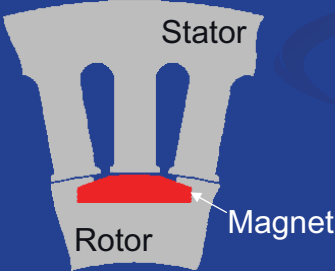
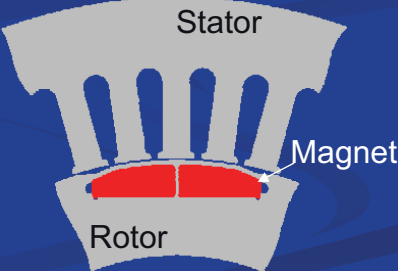
Reducing Vehicle Width



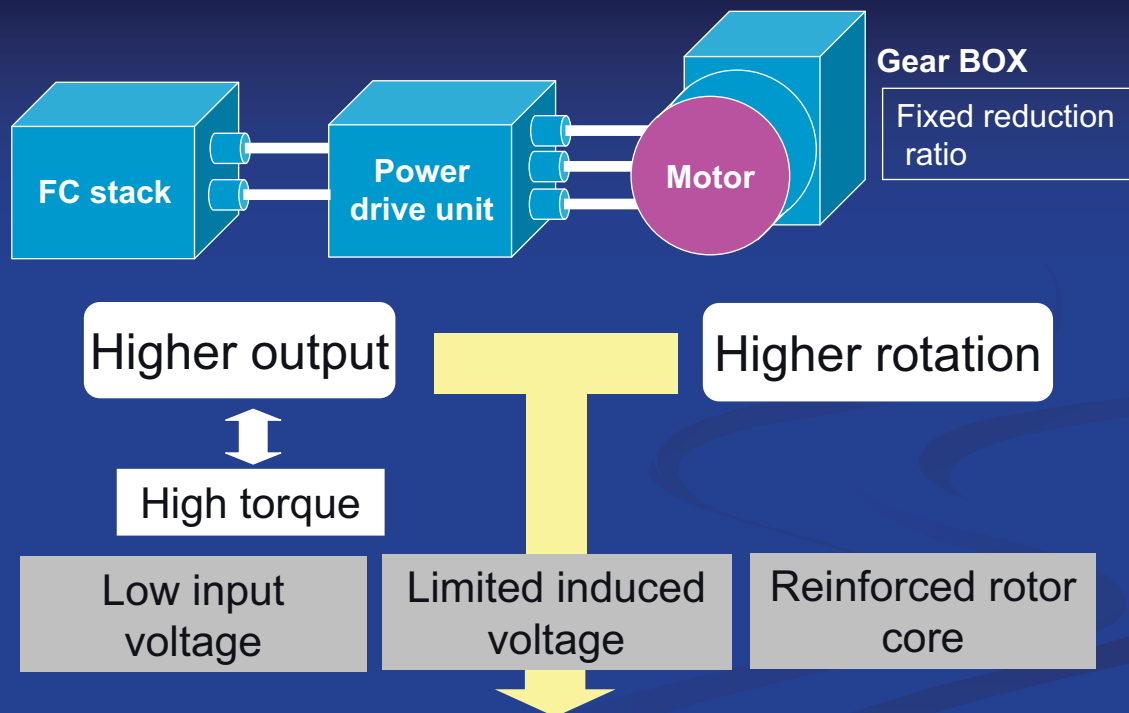
Configuration of internal oil lubrication
(FCX Clarity)

The vehicle width is reduced by eliminating the oil seal.

Comparing Magnetic Circuit Specifications

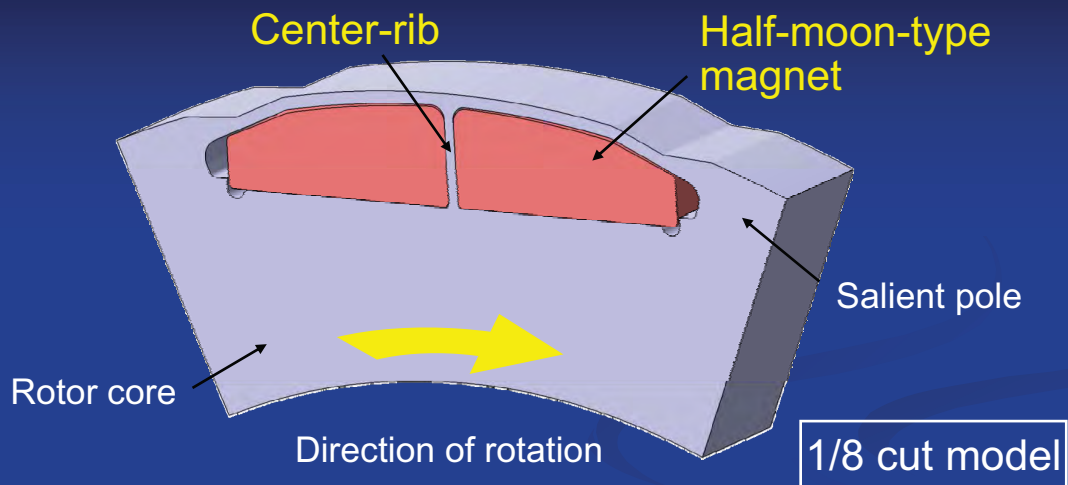
	2005M FCX	FCX Clarity
Type	PM synchronous motor	PM synchronous motor
Number of poles	12	8
Number of slots	36	48
Rotor type	Salient SPM	IPM
Magnet	Nd-Fe-B	Nd-Fe-B
Configurations (1pole)		
Cooling system	Water-cooled	Water-cooled

Higher Output and Rotation



A new IPM rotor is developed because of high output and rotation.

New IPM Rotor Development



The new type of IPM rotor offers:

- Higher output for low input voltages
- Effectively utilizing reluctance torque
- Decentralized rotor core stress during rotation

Approaches for Higher Output

$$P_{out} \gg \frac{EV}{w L_d} \sin d + \frac{1}{2w} \frac{E^2}{L_d} - \frac{1}{L_q} \frac{\omega^2}{\phi^2} \sin 2d$$

E : induction voltage

V : input voltage

L_d, L_q : d,q-axis inductance

d : internal phase angle

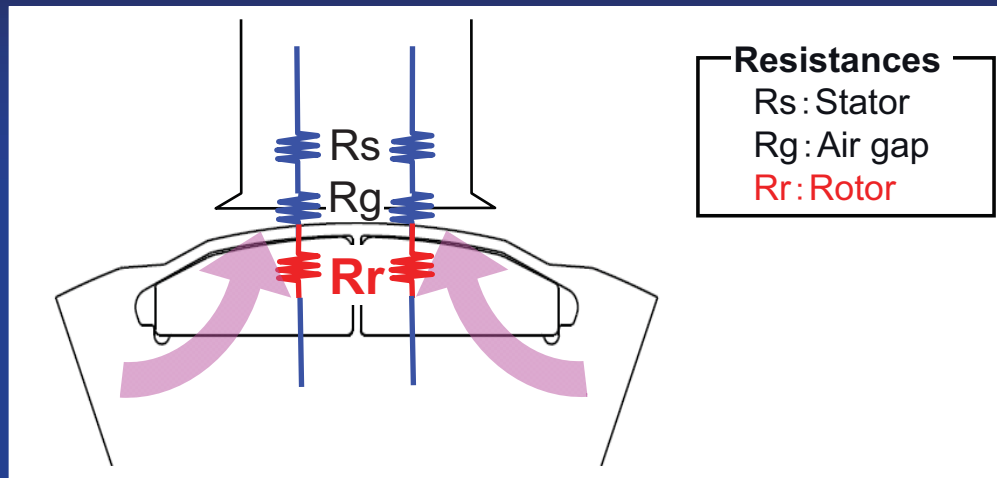
$E < \text{Allowed max voltage in primary}$

$V = \text{FC stack voltage}$



Reduced L_d to attain higher output

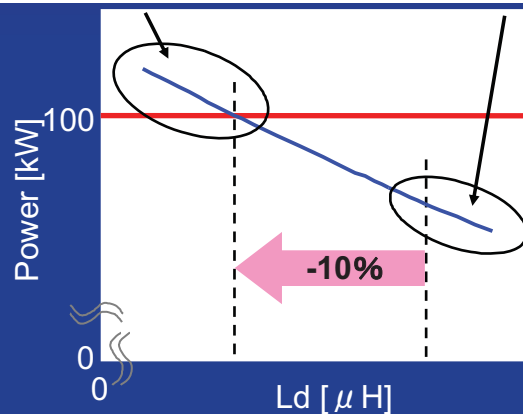
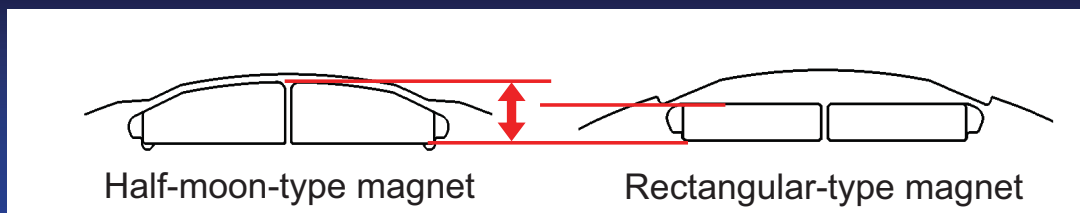
Reducing Inductance



Equivalent magnetic circuit of d-axis

Lowering inductance by increasing magnetic resistance of rotor

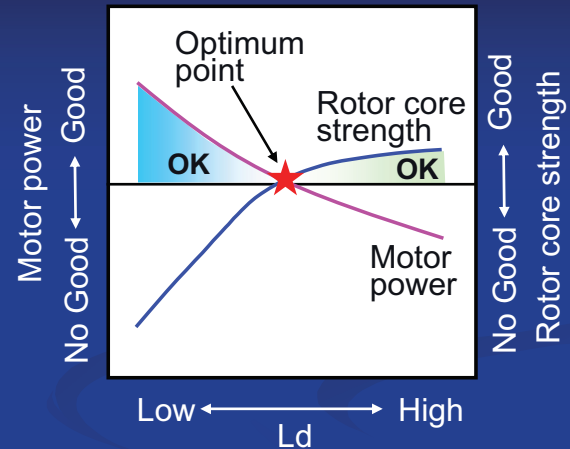
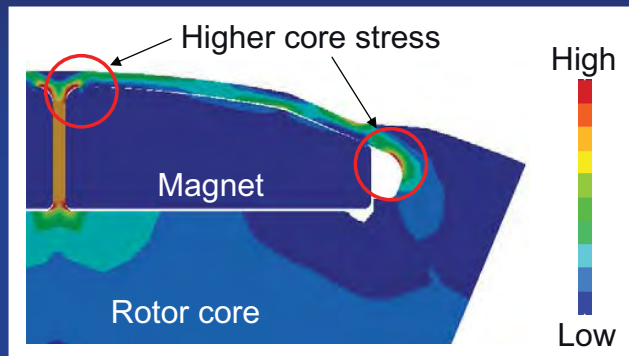
Low Inductance IPM Rotor



Relationship between d-axis inductance and motor power

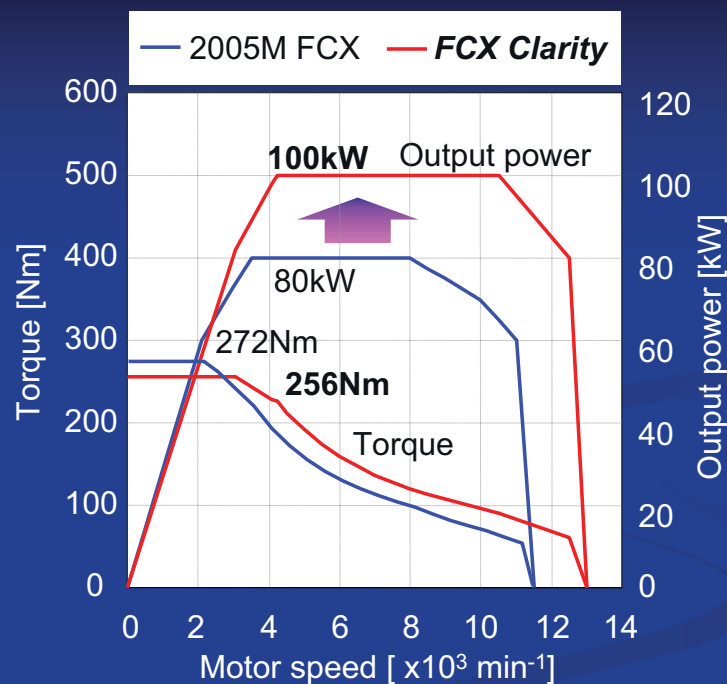
Higher magnetic resistance by increasing the thickness of magnets=Lower inductance

Maintaining Rotor Strength



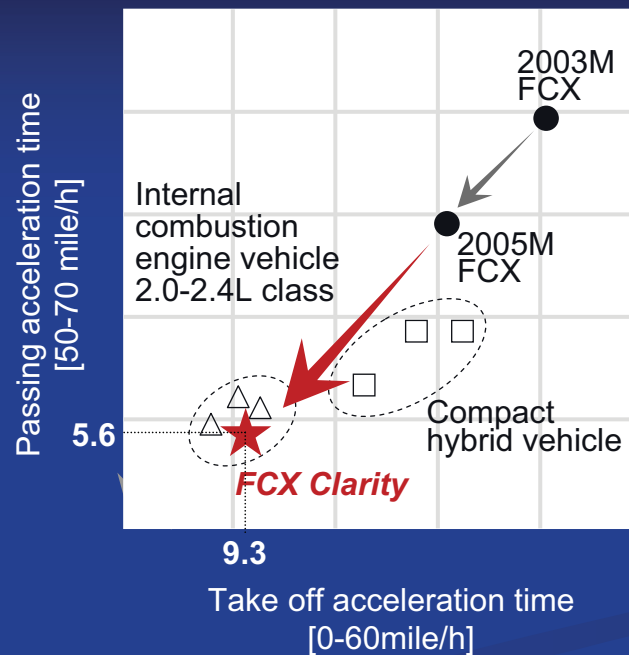
Achieved both inductance and rotor strength

Output Performance



Achieved a max output of 100 kW and max rotation speed of 12500 min⁻¹

Acceleration Performance



Achieved acceleration performance comparable to a 2.4 L class gasoline vehicle

Conclusion

- The drive unit was miniaturized by integrating the motor, gear box, and PDU
- Both higher output and higher rotation were achieved by utilizing an IPM rotor that maintains lower inductance and rotor strength.

FCX Clarity drive motor performance has vastly improved

Fuel battery vehicles contribute to achieving the most attractive automobile through these innovations.