

Heated and Cooled Seat for FCX Clarity

Harutomi NISHIDE*

Kenichi YOSHIKAWA*

Kazuhisa NAKAGAWA*

Hidenori ESAKI*

ABSTRACT

Heated and cooled seats have been developed using Honda's new "bio-fabric" material as a covering in order to enable adjustment of the vehicle cabin temperature for occupant comfort in an environmentally-friendlier manner that is appropriate for the FCX Clarity fuel cell vehicle, a vehicle that realizes the ultimate in clean performance. Thermo-control devices have been positioned in the cushions and backs of front seats (both U.S. and domestic specifications) and rear seats. These devices heat or cool air taken in by a blower, and the air is then directed towards the covering structure of the seat, which has been rendered permeable.

1. Introduction

In response to the environmental issues generated by the consumption of petroleum by automobiles, increased attention is being focused on environmental technologies centering on the use of next-generation energy sources that produce zero emissions and do not utilize fossil fuel resources.

Honda has been pushing ahead with the development of a fuel cell vehicle that is highly energy-efficient and utilizes hydrogen that can be created using natural energy sources, and the development of new bio-fabrics containing materials derived from plants. The company has also been working to increase the comfort of the vehicle interior by increasing the comfort of the temperature of the seat surfaces, part of the vehicle with which users are in direct contact and are therefore highly aware of. Seat heaters have been introduced, mainly in leather seats; a high-permeability covering ("space fabric") was employed in the 2000 model year INSIGHT, and "ventilation seats" were employed in the 2005 model year ACURA RL. Honda has also been involved in research on heated and cooled seats, in which the seat surface is directly heated and cooled, since 1995. This method of heating and cooling is fast-acting and reduces the operating load on the air-conditioner. For these reasons, heated and cooled seats were developed, in combination with the use of the Honda bio-fabric, for the FCX Clarity. This paper will discuss this technology.

2. Development Goals

The following three development goals were set in order to achieve a level of environmental performance appropriate for a fuel cell vehicle and comfortable heating and cooling performance, in addition to the basic functions of the seats and elements in the appeal of the vehicle.

- (1) Use of Honda bio-fabric as a covering
Use of the Honda bio-fabric, made by adding materials derived from plants. This would be the first time that a cloth covering had been used for a heated and cooled seat, offering a natural feel and texture. The use of the bio-fabric would also reduce CO₂ emissions due to the reduced reliance on petroleum in its production.
- (2) Achievement of a more comfortable heating and cooling function than previous systems
More rapid cooling than a ventilation seat and more rapid heating than a heated seat. Achievement of an equivalent level of fan noise and ease of operation to a ventilation seat.
- (3) Maintenance of functions and customer appeal of conventional seats
Employment of additional thermo-control devices, while maintaining the existing seat structures, original functions, and customer appeal of the seats.

3. System Configuration

3.1. Overall Configuration

Figure 1 shows an exterior view of the FCX Clarity

* Automobile R&D Center

in which the new heated and cooled seats are fitted, and Fig. 2 shows an image of one of the seats⁽¹⁾. Heated and cooled seats generally employ a configuration in which a single blower positioned in the seat cushion blows air over thermo-electric modules positioned in the seat back and the seat cushion. In the new seats, the seat cushion and seat back are each provided with a blower and a thermo-electric module, in addition to a seat surface temperature sensor. This enables independent control of air flow in the seat back and the seat cushion, increasing heating and cooling efficiency.

In addition, the fact that an air duct between the seat back and seat cushion was no longer required in order to connect the blower and thermo-electric module meant that no special seat frame was necessary, and that the heating and cooling function could be incorporated without modification of the basic seat structure. The thermo-electric modules in the seat backs have also been provided with exhaust ducts to guide waste heat outside the seats, helping prevent any increase in intake temperature due to heat being trapped in the seat backs.



Fig. 1 FCX Clarity



Fig. 2 Heated and cooled seat

As Fig. 3 shows, the operating switches have been positioned to the left and right of the air-conditioner operating panel, increasing user awareness that the switches operate a heating and cooling system.

3.2. Thermo-control Devices

As shown in Fig. 4, the blower and thermo-electric module that send air to the seat surface are connected into a single unit by a plastic duct. This unit is fixed by screws to brackets attached to the seat frame.

3.2.1. Blower

A thin, low-noise DC brushless motor and a sirocco fan have been used in the blower in order to increase customer appeal. In addition, as Fig. 5 shows, a removable filter has been fitted to the inlet, helping prevent infiltration of dust and foreign matter, and providing for easy replacement.

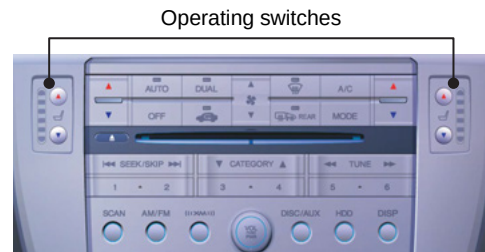


Fig. 3 Location of switches

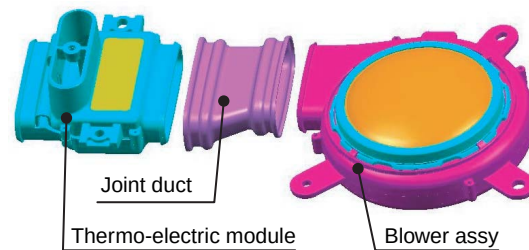


Fig. 4 Thermo-control device

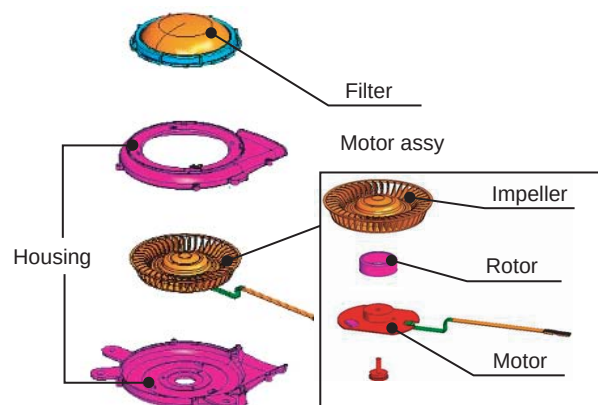


Fig. 5 Blower assy

3.2.2. Thermo-electric module

As shown in Fig. 6, the thermo-electric module is composed of a Peltier module, in which switching between heating and cooling is determined by the direction of the current, sandwiched between radiators above and below. This unit is fitted within a plastic housing. Air from the blower passes across the radiator above the Peltier module and its temperature is adjusted, after which it turns 90° and passes out the top of the unit. Unnecessary heat produced by heat exchange is exhausted at the side. Temperature sensors are positioned on the electrodes of the Peltier module, enabling the temperature of the seat surface to be monitored.

3.3. Control Unit

Relays are generally employed to drive a Peltier module, enabling the current that flows during heating and during cooling to be reversed. On the other hand, the modules employed in the new seats are composed of semiconductor relays using Field Effect Transistor (FET), which has contributed to increased durability and

reliability due to contactless configuration, and enhanced customer appeal due to silent switching.

3.4. Air Channels

As Fig. 7 shows, ditches have been formed in the surfaces of the pads used inside the seat backs and seat cushions in order to direct the air that has been heated or cooled by the thermo-electric modules positioned behind them to the covering structure of the seats. Because cloth has been used as the seat covering for the first time in these seats rather than the leather previously used for heated and cooled seats, plastic plates have been positioned above these ditches (Fig. 8) in order to help prevent a reduction in the air flow due to the ditches constricting when the occupant sits in the seat, reduce the appearance of dents in the surface of the seat, and to minimize occupant discomfort. In addition, adjustment of the position, size, and shape of holes in the plastic plates has increased the efficiency of air supply. Figure 9 shows the results of an analysis of the effects of the plates conducted with and without the plates using computational

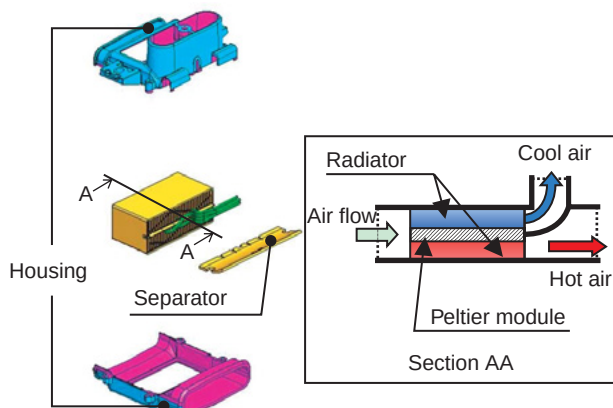


Fig. 6 Thermo-electric module



Fig. 7 Ventilation ditches

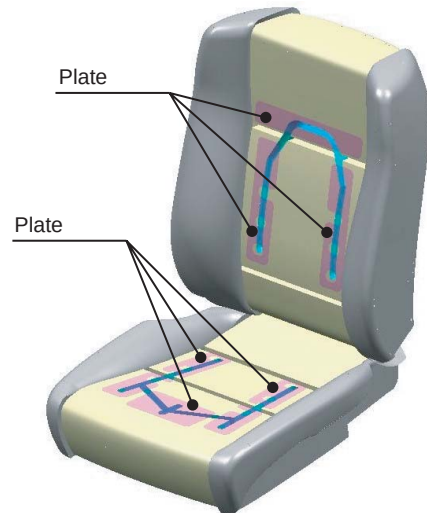


Fig. 8 Plates employed on ditches

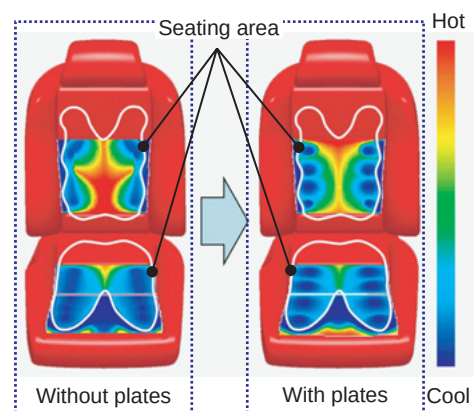


Fig. 9 Results of CFD analysis

fluid dynamics (CFD). These results indicate that adding the plates increased cooling efficiency around the center part of seating area.

3.5. Covering Structure

Figure 10 shows a cross-section of the structure of the seat covering. The use of a permeable foam for the wadding underneath the covering has helped to ensure high permeability and made the surface pleasant to the touch. Figure 11 shows a view of the appearance of the Honda bio-fabric used as the covering material⁽²⁾. The surface has been covered in tiny holes in the same way as the leather previously used in heated and cooled seats, offering an image of high permeability.

3.6. Operating Switches

The operating switches are the same type previously used for the ventilation seats in the ACURA RL. The LED indicator shows that the system is functioning, and lights in red when the seat is being heated or in blue when being cooled.

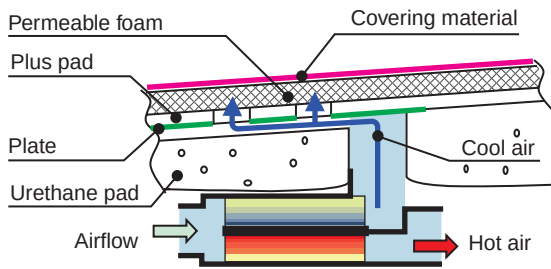


Fig. 10 Structure of seat covering



Fig. 11 Seat covering material (Honda bio-fabric)

4. Heating and Cooling Control

Figure 12 shows the configuration of the heating and cooling control system. Heating and cooling each have three operating modes, High, Mid, and Low. The seat surface target temperature is determined based on the

operating mode selected via the switch, and the amount of heat output by the Peltier module is controlled. Upper and lower limits have been set for the High modes in order to help prevent discomfort due to excessive heat when heating the seat and excessive cold when cooling the seat. The target temperatures for Mid and Low modes have been set to enable users to be aware of a difference between the modes.

4.1. Peltier Control

To achieve the heat output from the Peltier module, the seat surface target temperature, per the selected operating mode, is determined by information from temperature sensors in the seat surfaces and Peltier sensors, and is fed-back to the Peltier output. This helps to prevent overshooting or undershooting the seat surface temperature, and has reduced the time required to reach the target temperature.

4.2. Blower Control

The air flow is controlled using tables of motor voltage derived from operating mode and elapsed time. The control also compensates for the difference between the target temperature and seat surface temperature.

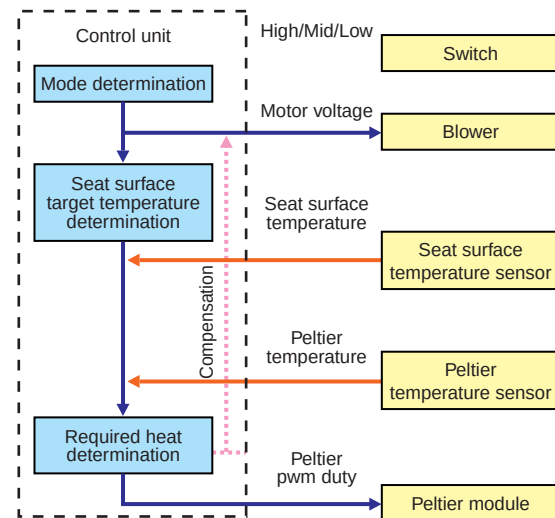


Fig. 12 Heating and cooling control system

5. Performance

The cool-down and heat-up characteristics of the new seats are shown in Figs. 13 and 14 respectively. These results show clearly that the new heated and cooled seats increase occupant comfort more rapidly than the previous ventilation seats or heated seats.

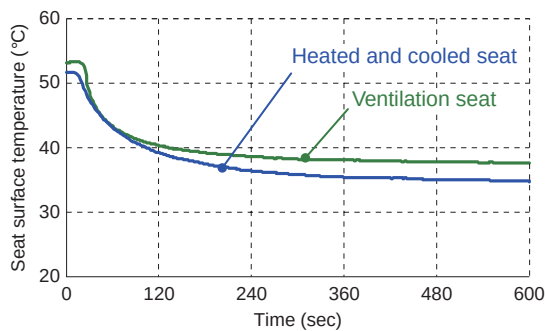


Fig. 13 Cool-down characteristic

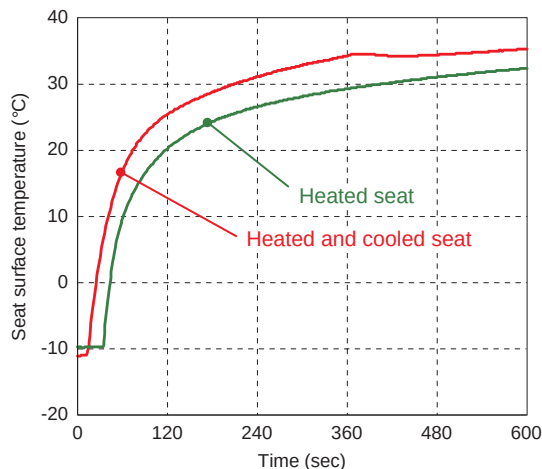


Fig. 14 Heat-up characteristic

6. Conclusion

Heated and cooled seats have been developed as a new means of increasing occupant comfort. The following results were obtained from this development project:

- (1) Use of the new seat heating and cooling system in combination with Honda's new bio-fabric material has enabled the realization in an environmentally-friendly manner of a comfortable texture that is appropriate for a fuel cell vehicle.
- (2) The use of Honda-developed control methods has enabled the achievement of more rapid heating and cooling performance than the previous ventilation seat or heated seat.
- (3) Efficient positioning of thin and lightweight thermo-control devices has enabled the seats to be provided with heating and cooling functions without compromising their basic functions or sacrificing customer appeal.

References

- (1) <http://www.honda.co.jp/factbook/auto/FCX-CLARITY/200807/11.html>, 2008/7/2
- (2) <http://www.honda.co.jp/e-dream/backnum/archive/e-dream12/special8.html>, 2006/10/1

■ Author ■



Harutomi NISHIDE



Kenichi YOSHIKAWA



Kazuhisa NAKAGAWA



Hidenori ESAKI