Development of "i" Concept Test Car for 2003 IAA and 2003 Tokyo Motor Show

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Abstract

The "i" is a concept test car developed by Mitsubishi Motors Corporation (MMC) in line with a 'small and surprising' theme. Built on a midship-engine/rear-wheel-drive (MR) platform, it combines a small body with class-topping comfort and crashworthiness. Further, the "i" is the first vehicle in its class to earn five stars (the highest score) for both fuel economy and emissions performance in the Federation International de l'Automobile (FIA) EcoTest (as administered by the Allgemeiner Deutscher Automobil Club (ADAC)). Factors enabling this outstanding performance include an environment-friendly powertrain (this incorporates a 1.0-liter MIVEC engine and a Mitsubishi Smart Idling System), minimal weight (achieved through extensive use of plastics and aluminum in the body and chassis), and maximized aerodynamic performance.

Key words: *Motor Show, Light Weight, Low Fuel Consumption, Concept Car*

1. Introduction

MMC has for many years been expanding and refining its base of development technologies for minicars and other small cars. Against this background, MMC has identified a need for new proposals on vehicle configurations, which are becoming increasingly uniform. At the same time, the Japan Automobile Manufacturers Association has voluntarily adopted a target of 140 g/km or less for average carbon-dioxide (CO_2) emissions among passenger vehicles made for the European Union, thus increasing the need for automakers to develop small cars with extremely low fuel consumption. As a response to these needs, MMC refocused on the challenge of finding ways to achieve a spacious interior environment and extensive design freedom within the limited dimensions of a small car while also giving form to the three main MMC brand attributes of passion, performance, and perfection. At the 2003 Frankfurt International Motor Show, MMC unveiled the result of its study: the "i" concept test car (**Figs. 1** and **2**), which combines ultra-low fuel consumption with class-eclipsing comfort and safety and a stylish design. An overview of the "i" is given in this paper.

Fig. 1 Exterior

Fig. 2 Interior

2. Features

Key features of the "i" include

(1) a newly developed MR platform that permits a simple and unique one-motion form together with superior comfort and crashworthiness;
(2) ultra-low weight, outstanding aerodynamics, and a newly developed engine that together realize ultra-low fuel consumption; and
(3) future-oriented applications of information technology (IT).

3. Newly developed MR platform

The MR platform, which locates the engine behind the passenger space but within the wheelbase, was newly developed for the "i" (**Fig. 3**). Notwithstanding the vehicle's modest external dimensions, this platform permits a long wheelbase, which in turn permits a spacious cabin (big enough to accommodate four people in comfort), superior ride comfort, outstanding crash-

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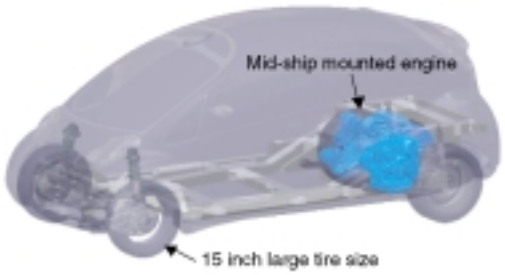

Fig. 3 MR platform

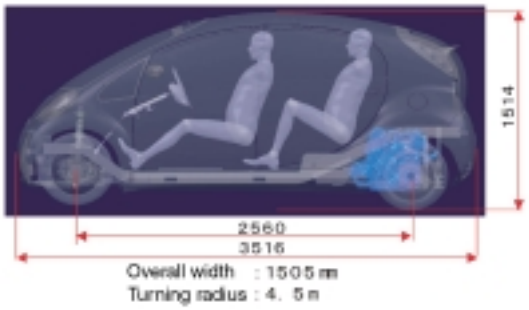

Fig. 4 Packaging

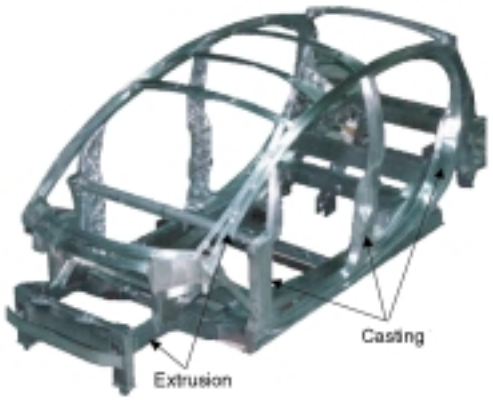

Fig. 5 Aluminum space frame

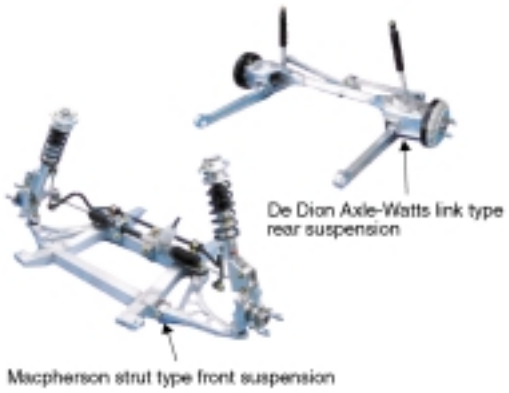

Fig. 6 Lightweight suspension system

Fig. 7 Testing of full-size vehicle in wind tunnel

Fig. 8 Airflow over roof spoiler

worthiness, and ample pedestrian-protection performance (**Fig. 4**).

4. Fuel-saving technologies

(1) Body

The body is based on an aluminum space frame, and the hood, doors, front fenders, tailgate, and other panels are formed from ultra-light plastics. In the space frame, the latest hybrid laser welding technology was used to realize high-strength, high-precision welds between aluminum extrusions and aluminum die-castings, resulting in a 35 % weight saving over a steel space frame (**Fig. 5**).

(2) Chassis

In the suspension system, MacPherson struts are used at the front and a De Dion axle with Watts linkage is used at the rear (**Fig. 6**). Weight is minimized by extensive use of aluminum for the suspension members, lower control arms, struts, steering knuckles, brake rotors, brake calipers, shock absorbers, and other chassis components, by adoption of hollow suspension stabilizers, and by adoption of coil springs made of high-tensile steel. Also, low-friction ceramic wheel bearings and measures to minimize brake drag keep running resistance to a minimum.

(3) Aerodynamic performance

By adopting a rounded one-motion form (rather than the boxy styling that automakers typically use to maximize space efficiency) and by shape-optimizing the rear spoiler, the door mirrors, the fenders, and the bottom surface of the body, MMC gave the "i" outstanding aerodynamic performance that's reflected in a drag coefficient of only 0.24 (**Figs. 7** and **8**).

(4) Powertrain

For ultra-low fuel consumption and easy driving, the

Fig. 9 Newly developed engine

Fig. 11 Functions of information key

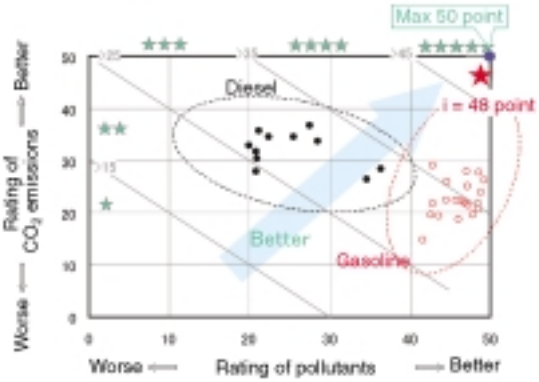

Fig. 10 Results of FIA EcoTest administered by ADAC

powertrain of the "i" combines a newly developed high-efficiency gasoline engine with a continuously variable transmission and incorporates a Mitsubishi Smart Idling System, which stops the engine when the vehicle is stationary.

① Newly developed engine

The "i" is powered by a newly developed 1.0-liter, three-cylinder, DOHC, 12-valve engine (**Fig. 9**). Lightness and compactness are realized by features including an aluminum cylinder block, a valvetrain in which the valves are actuated directly by the camshafts, and a silent camchain. Combustion efficiency is maximized by a Mitsubishi Innovative Valve timing and Electronic Control (MIVEC) system, which optimally varies the intake- and exhaust-valve timing. And losses are minimized by features including low-tension piston rings and exhaust-gas recirculation. The overall result is a combination of high performance (maximum output is 50 kW at 6,000 rpm; maximum torque is 92 Nm at 3,500 rpm) and low fuel consumption.

② Mitsubishi Smart Idling System

The Mitsubishi Smart Idling System stops the engine when the vehicle is stationary and restarts it when the driver prepares to pull away. It has a 14 V belt-drive starter/generator unit that enables it to restart the engine rapidly and without noticeable vibration.

(5) Exhaust emissions and fuel economy

In the FIA EcoTest (as administered by the ADAC), the "i" satisfied the Euro 4 exhaust-emissions standards and achieved CO_2 emissions of 89 g/km (with fuel consumption of 3.8 L/100 km) – lower than the 90 g/km limit defined for so-called three-liter cars. The "i" is the first vehicle in its class to earn five stars (the highest score) for both fuel economy and emissions performance in the FIA EcoTest (**Fig. 10**).

(6) Environment-oriented construction

In addition to the fuel-efficiency advantages yielded by its lightness, the "i" reflects the benefits of an environment-oriented structure. Recyclability is promoted by component joints that facilitate dismantling and by minimal use of urethane in the seat cushions and other parts of the vehicle.

Emissions of CO_2 are minimized not only by the vehicle's lightness but also by the use of a plant-based plastic for the cargo space floor board. Use of lead (a substance that creates an environmental burden) is also minimized.

Further, the lightweight body was subjected to a life-cycle assessment and found to offer superior environmental characteristics throughout its lifecycle.

5. Future-oriented IT applications – Information key

(1) Overview

The "i" provides the driver with an 'information key' that fits into a bay in the center of the instrument panel. This unit has a number of vehicle-control functions (including verification of the user's identity) and can be used as a display- and memory-equipped portable audio player and for electronic financial transactions (**Fig. 11**).

(2) Functions

① Automatic keyless entry

When the driver carrying the information key approaches the vehicle, the key, which incorporates a transponder with an antenna, communicates with a vehicle-mounted unit, confirms the user's identity, and causes the doors to be unlocked. When the driver carrying the key moves a certain distance away from the vehicle, the doors are automatically locked. When the driver fits the key into its bay in the center of the instrument panel, the key begins communicating with the vehicle-mounted unit by means of Bluetooth wireless technology. By verifying the driver's identity, the key then disengages an immobilizer, allowing the driver to

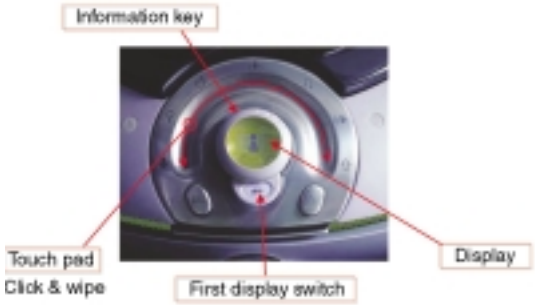

Fig. 12 Operating method for information key

start the engine by pushing a start button.

② Entertainment

The key provides control over FM/AM radio reception. Also, it incorporates a slot into which a memory card containing digital music or photo data can be inserted for playback inside or outside the vehicle as desired.

③ Navigation

The key can give the driver directional instructions in the form of arrows on its display based on data from a vehicle-mounted navigation-system head unit. Also, the key enables the driver to set the vehicle's destination and download it to the vehicle-mounted unit by means of a memory card.

④ Indication of vehicle status

The key shows vehicle-status information including fuel consumption, the outside temperature, and the distance driven.

⑤ Recording of vehicle-maintenance data

The key records vehicle-maintenance information on an embedded memory card. Dealers can use this information for diagnosis purposes when they service the vehicle.

⑥ Electronic financial transactions

The key can be used as a wireless terminal for credit-based financial transactions such as payment of highway tolls and payment for shopping.

(3) Operating method

The driver selects functions by drawing a fingertip over an arc-shape touch pad and then double-clicking (**Fig. 12**).

By enabling the driver to access functions using this simple method, which resembles the operating method used with notebook computers, the information key represents a totally new means of display and control – one whose modest space requirements make it ideally suited to compact cars and whose functionality suggests new lifestyle possibilities.

6. Summary

By employing a newly developed MR platform, MMC's development team successfully realized a concept test car with unique styling and superior comfort and crashworthiness. And by comprehensively addressing the challenge of finding ways to minimize fuel consumption without using unduly complex systems, the team achieved outstanding fuel economy (as evidenced by the vehicle's performance in a test administered by the ADAC). MMC will now work on refining the technologies it adopted in the concept test car with a view to using them in production vehicles.

In closing, the development team wishes to express sincere appreciation to everyone inside and outside MMC who co-operated in the development of the concept test car.

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