Development of Materials during Third Formula One Era

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ABSTRACT

The realization of high-power and high-efficiency powertrains, lightweight and compact vehicle frameworks, and a high level of durability and reliability are necessary to increasing the competitiveness of Formula One race vehicles, and material technologies are an essential factor in this. Honda has developed high-strength, high-stiffness, and low-density materials such as titanium-aluminum and aluminum metal matrix composite (MMC) materials in order to achieve weight-savings in structural parts. The company has also developed low-friction and high-durability surface modification technologies, in particular DLC coatings, for friction materials. For use in hybrid systems, Honda has developed magnetic materials for use in motors and highly functional materials such as high-thermal-conductivity materials. These material technologies have enhanced vehicle performance and increased race competitiveness.

1. Development of Materials during Honda Formula One Third Era

The role of Honda's Materials Division in the company's Formula One activities during the 1980s centered on the development of technologies for the enhancement of materials that would enhance engine performance. In the process of development of race vehicles for the company's third era activities commencing in 2000, that role evolved to the development of advanced materials of the type used in the aerospace industry and their application throughout the vehicle, from the powertrain onwards. This process involved rapid changes of a type not previously experienced, and the Formula One third era became a demanding period in which the Formula One team faced a variety of technological development challenges.

At the beginning stages of Honda's third era activities, the European and U.S. teams had already established a technological foundation in advanced technologies developed in the aerospace industry, and were striving to apply these technologies in Formula One. Having ceased its Formula One activities, Honda was delayed in its own efforts in this direction, and the company fell behind its competitors in terms of technological advancement. Precision casting technologies for titanium and steel materials for gears and cranks can be pointed to as representative examples. Because of this technological lag, the enhancement of Honda's development program to enable the company to quickly catch up with and overtake the leaders in the field, the European teams, was an important issue at the time. Given this, the Materials Division actively sought out and introduced not only domestic but also European and U.S. technologies, and proceeded with development programs aiming to create materials technologies surpassing those of other teams. While a later change in circumstances reduced the need for precision casting technologies, in the area of structural steels the company developed high-strength gear materials and high-toughness steels for use in cranks, and began to employ them in races. Later, the practical use of high-strength, high-rigidity materials such as titanium and aluminum metal matrix composite (MMC) materials became feasible, and Formula One teams entered a stage of fierce development efforts. Although research efforts in these areas had diminished in Japan, these were fundamental technologies for the aerospace industry, and research was ongoing in Europe and the U.S. Honda also made concerted efforts at development, and established its own processes for manufacturing high-strength materials. This resulted in the development of titanium-aluminum valves and piston pins and aluminum MMC pistons, which were subsequently employed in race vehicles.

In 2002, Honda made the transition from conventional bucket tappet valvetrains to rocker arm valvetrains, which enabled the achievement of increased engine speed and enhanced performance. Tribological technologies for the friction components formed an important aspect of these development efforts, and surface modification technologies were an essential research focus which would affect the feasibility of the new mechanisms. As in the case of structural materials, Honda sought out technologies, including technologies developed overseas, and developed a diamond-like

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carbon (DLC) coating as a new surface modification technology. This technology significantly increased the durability of the friction components of the camshaft and rocker arms of the new mechanism, and contributed to making it technologically feasible.

Moving in another direction to the development activities outlined above, discussions intensified among the Federation Internationale de l'Automobile (FIA) and participating teams regarding the reduction of the excessive development budgets resulting from competition for technological development, and from 2006 materials regulations were enhanced.

In order to minimize the possibility for losses from having technologies that had already been developed and put to use rendered ineligible for use, Honda continued development efforts situated within the scope of the materials regulations. As a result, new ideas emerged, and Honda proceeded with the development of conrod bearings using a high-thermal-conductivity material as the back metal and technologies for the enhancement of the performance of the DLC coating. These technologies increased powertrain efficiency. In particular, in the area of DLC coatings, a technology resistant to high surface pressures was developed enabling the previous limit in surface pressure to be exceeded. The application of this technology from the shift to the bevel gears of the transmission increased Honda's race competitiveness. In the period from 2007, the final period of the company's third era activities, Honda also focused on development efforts in the area of functional materials for the development of hybrid systems, the use of which changes in regulations had made possible from 2009 onwards. Aiming to reconcile hybrid device performance, the framework structure, and durability, the company conducted development efforts in the areas of magnetic materials for use in motors and high-thermal-conductivity materials to enhance the cooling performance of power control units, and succeeded in developing new materials technologies.

2. Direction of Materials Development

This chapter will discuss the direction of development of materials technologies for race vehicles as a whole, including the technologies discussed above. The elements composing race vehicles are engines, transmissions, chassis, and hybrid systems, and as Fig. 1 shows, there are four basic directions for the development of materials enabling the realization of the necessary characteristics of each element. It is essential to maximize the functions of these basic materials and thus enhance the competitiveness of the race vehicle.

High-strength, high-stiffness, and low-specific-gravity materials, both metallic and non-metallic, are a key technology in the achievement of improved performance and durability in race vehicles, from the engine and transmission components and the framework structures to the suspension and the brakes.

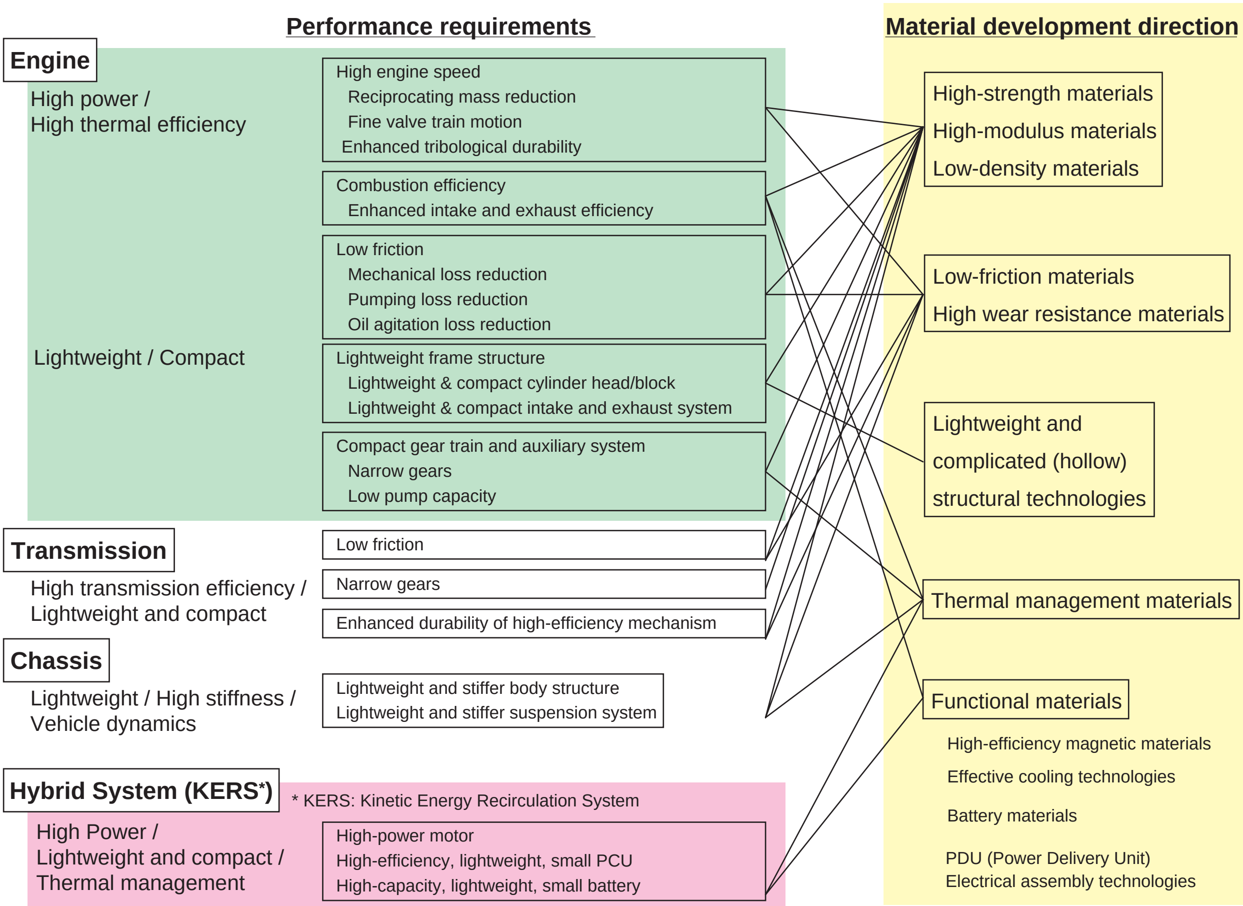

Fig. 1 F1 material development

Low-friction and low-wear materials are an important technology directly related to the achievement of enhanced vehicle efficiency by reducing friction resistance in the engine and in friction components throughout the vehicle and enabling components to be used under extremely severe conditions.

Thermal management material technologies, which enable control of the heat balance, are important in enhancing the functions of each part of the vehicle, including the enhancement of thermal efficiency around the engine and brakes and the cooling of the hybrid system. This is achieved, for example, by means of exploitation of the thermal conductivity of base materials and the heat absorption and dissipation characteristics of surfaces.

In the area of functional materials, magnetic materials for use in fuel injectors are necessary in engines, and magnetic materials, materials with excellent thermal conductivity and thermal insulation characteristics, battery materials and others are important technologies in enhancing the functions of the motors, PCUs, and energy storage devices used in hybrid systems.

3. Conclusion

For examples and more detailed discussion of Honda's work in the development of materials technologies, the reader is referred to the special edition of the Technical Review dealing with materials[(1)-(18)]. While few of these materials are employed in mass-production vehicles due to cost, the knowhow and guidelines in the area of element technologies gained from their development do encompass aspects that can be extensively used in development for mass production. In conclusion, the author wishes to express his sincere gratitude to Honda's suppliers, both domestic and international, for their generous assistance in these development projects.

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