II. R&D and Intellectual Property in Main Businesses

By further promoting advanced technologies and making the best of the group's overall competitiveness, the Hitachi Group has introduced and maintained products achieving the largest or the second-largest market share in the Social Innovation Business and Infrastructure Technology/Products, thereby solving problems faced by Japan and the world. Below are three examples of such product solutions.

1. High Efficiency Coal-fired Power Plant Incorporating Advanced Environmental Technologies

With its rich reserves and affordability compared to other fossil fuels, coal is used to generate almost forty percent of all electricity produced in the world, and is expected to continuously play an important role in power generation. However, it is significant challenge for coal fired power generation to reduce emission of greenhouse gasses in its flue gas since coal fired power plants emit more greenhouse gasses such as nitrogen oxides (NOx), sulphur oxides (SOx) and carbon dioxide (CO_2) comparing to other power generation methods, as the demand for mitigating environmental impact have increased in recent years.

Hitachi Group is one of the first companies that introduced supercritical pressure boiler with high efficiency and low-NOx combustion technology and desulfurization and denitrification technologies that mitigate environmental impact, and has demonstrated significant performance both in Japan and abroad. (Fig. 2.1) Moreover, Hitachi is the only power plant manufacturer that produces denitrification catalyst in-house, and its long product life and high performance have allowed Hitachi to gain more than thirty percent of the world market share.

In 2005, Hitachi completed a high-efficient supercritical coal-fired power plant in Alberta, Canada that was the first of its kind built in North America. (Fig. 2.2) The new coal-fired power plant was highly appreciated in North America since, compared to the conventional plants, it improved the efficiency by 18% (18% less coal is used to generate the same output, reducing CO_2 emission by 18%), reduced NOx in flue gas by 40% and cut SOx by 70%.

To promote further development of environmental technologies, Hitachi built in March 2007 one of the largest coal combustion experiment facilities that can demonstrate the combustion characteristics equivalent to that generated in an actual coal-fired power plant. That allowed Hitachi

Fig. 2.1 Flue Gas Denitration Equipment of Ninghai Power Plant, China (enlarged photo at top left)

Fig. 2.2 The first supercritical coal fired power plant in North America

to have the prospect of developing a new combustion system and further reducing NOx in flue gas by half.

With respect to CO_2 which is deemed as one of the greenhouse gases, Hitachi developed in mid-1990's a system to capture CO_2 contained in flue gas, and now plans verification tests in Europe.

Thanks to IP activities in coordination with business and R&D activities, about 1,200 patents relating to boiler and flue gas treatment technologies have been granted in Japan and abroad.

In recent years, Hitachi has focused on patenting activities meeting such developments and promoted IP activities reinforcing competitiveness of overseas businesses.

Hitachi group contributes to global-scale environmental conservation in the future by accumulating development of boiler and flue gas treatment technologies capable of supplying energies while maintaining the environment clean.

2. Hybrid Propulsion System for Railways

Since 2001, Hitachi and East Japan Railway Company (JR East) have jointly developed environmentally friendly hybrid propulsion system, which successfully resulted in the world's first commercial operation on Koumi line in July 2007.

In recent years, air pollution caused by industrial and vehicle emissions, global warming caused by CO_2 and other environmental problems have made the headlines together with energy issues such as fossil fuel depletion.

In the field of railcars, Hitachi has made efforts to reduce power consumption with "regenerative braking system" in addition to "weight reduction" and "equipment efficiency" as part of our engagement in energy and environmental problems. In respect of DMUs (Diesel Multiple Units) for non-electrified lines, however, regenerative braking system is not applicable because such a car is directly driven by diesel engines.

The hybrid propulsion system enables a railway motor car to use regenerative braking system, thereby promoting reuse of regenerative energies and high-efficiency engine operation to reduce energy consumption and hazardous emissions.

The system constitutes a series hybrid drive system consisting of a diesel engine and high energy-density lithium ion batteries, and has realized (a) reduction of environmental burdens, (b) higher railcar performance and (c) less maintenance. It was incorporated and put into practice as the hybrid drive system in Series E200 DEMU (Diesel Electric Multiple Unit) of JR East.

Compared to conventional DMUs, the DEMUs introduced to the Koumi line, for instance,

Fig. 2.3 JR East's Series E200 Motor DEMU incorporating hybrid propulsion system

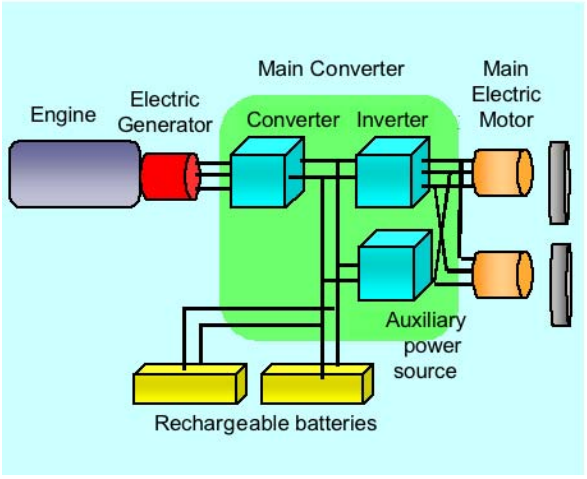

Fig. 2.4 Structure of hybrid propulsion system

has reduced energy consumption by 10% and hazardous emissions by 60%.

What is important with this system is the energy management that coordinates and controls energy supply to the engine, generator, batteries and main electric motor, which is carried out by engine and main converter and inverter controllers. To be more specific, appropriate battery charge level and travelling performance are maintained by controlling the engine generator system in response to train speed and state of charge level in the main circuit.

In practice, the engine generator stops while the railcar is stopping at train stations to prevent noise emission and improve fuel consumption, and starts to operate again when departing stations. The train accelerates solely with battery power until the speed reaches to about 30km/h. During the power running, the engine generator helps the power output. When regenerative braking system is put in action, the engine generator stops operation, and the regenerative power is absorbed in storage battery. If the battery becomes fully charged when the braking system operates to suppress the speed, the engine brake absorbs regenerative power to prevent overcharge.

To further improve fuel consumption, gradient prediction control is in place to efficiently use potential energy.

As to IP activities relating to railcar hybrid drive system, efforts have been made for strategic registration and maintenance of patents relating to railcar drive control and energy management system. As of the end of FY 2007, nearly 100 patent applications are pending in Japan. R&D activities and patenting activities in this field will be further coordinated based on the understanding that the technology continues to play the key role in Japan and abroad.

3. Disk Array Subsystem Featuring Storage Virtualization

As business operations diversify and data volume keeps growing in ever-changing business environments, there are increasing needs for a storage system that can reliably retain and utilize data and improve utilization of storage infrastructure. To meet such needs, an information systems manager needs to improve utilization of storage infrastructure by, for instance, enhancing the storage system as necessary and integrating the storage.

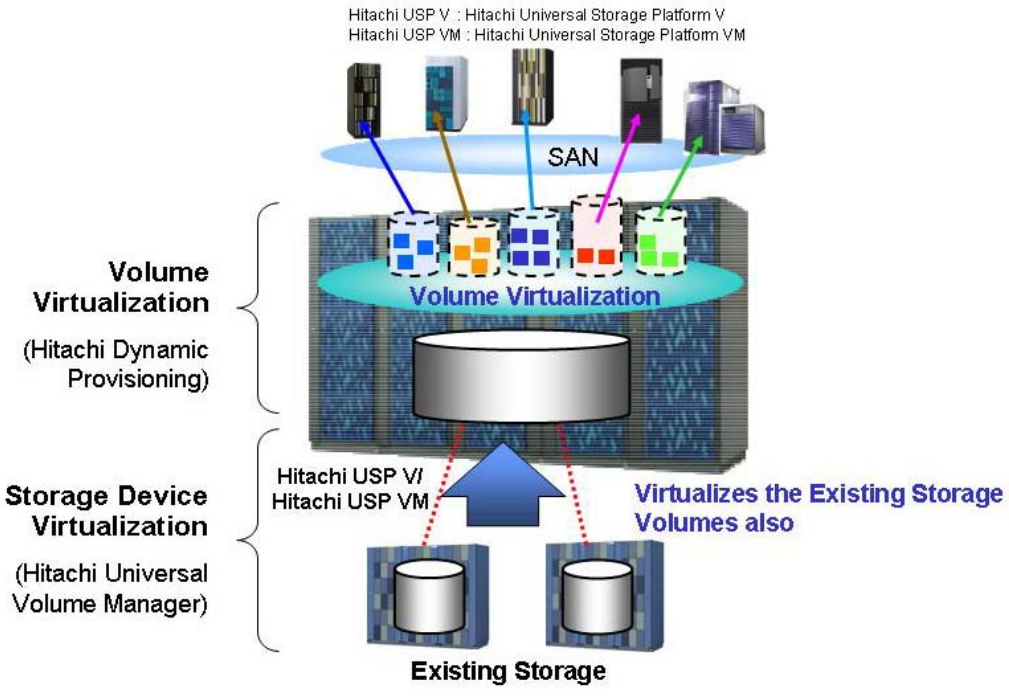

Fig. 2.5 Disk array subsystem featuring storage virtualization

As unstructured data such as images and video increases in recent years, it is hard to predict the data volume. Sometimes data volume increases at an unexpected pace, resulting in under-utilization of deployed storage capacity. According to a study, only 30–40% of the storage capacity is actually used in a general Storage Area Network (SAN) environment, which suggests that improving the utilization will contribute to the reduction of cost for introducing, managing/operating, and running storage systems. Thus there is an increasing need to improve storage capacity utilization to reduce those costs.

To meet such demands, Hitachi has realized storage virtualization at disk array controller.

In September 2004, Hitachi introduced "Hitachi Universal Volume Manager" which virtualizes multiple, heterogeneous storage and enables 'single-pane-of-glass' management/operation. This also enables effective utilization of existing storage as part of the disk array subsystem, Hitachi USP V/Hitachi USP VM. Moreover, it increases the value of existing storage system because the newest functions of Hitachi USP V/Hitachi USP VM are applicable across the entire virtualized storage systems.

"Hitachi Dynamic Provisioning" which was introduced in May 2007 virtualizes storage capacity and allows for larger volume definitions independent of the physical storage capacity. By optimizing the data allocation in the real storage area, it maximizes storage utilization and improves customers' storage ROI (Return On Investment), while reducing energy consumption in the storage system and improving the running cost.

Hitachi's disk array controller-based storage virtualization has been highly acclaimed by numerous customers for its reliability, performance and functions, and more than 9,100 units have been shipped so far worldwide (as of the end of March 2008). It has also been awarded with the 50th Best New 10 Products Awards–Nippon Brand Prize–in 2007 by Nikkan Kogyo Shimbun Ltd. for the product's unique technology and significant competitiveness Hitachi's IP activities related to storage virtualization technology have been focused on creation of patents as well as fostering them under its IP strategies, fully taking into account the business and R&D perspectives in the worldwide R&D environment. As a result, about 650 patent applications are pending in Japan and abroad as of the end of 2007 while about 120 patents have already been granted outside Japan. We will continue to strengthen our patenting activities in Japan and abroad.