Ultra Large Hydraulic Excavators and Dump Trucks for Large Open-pit Mines

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OVERVIEW: The high performance and superlative reliability of Hitachi Construction Machinery Co., Ltd.'s ultra large hydraulic excavators have earned them the leading share of the international open-pit mine market. In the field of dump trucks, meanwhile, a new 190-t class model went on sale in 2008 and a 220-t model in 2010 both of which are fitted with Hitachi, Ltd.'s latest AC-IGBT electric drive system. These dump trucks are used together with Hitachi's ultra large hydraulic excavators in increasing numbers having built up an excellent reputation at the world's mines. Hitachi Construction Machinery is also developing new models that incorporate a system for fault diagnosis that utilizes monitoring data from the mining machines to maintain a high level of utilization. This development includes improvements to capacity and reliability as well as paying attention to environmental compatibility and energy efficiency.

INTRODUCTION

WORLD demand for resources is growing and is recovering rapidly from the effects of the economic recession that followed the Lehman shock financial crisis and which in any case were quite small. This has also created growing demand from the world's mines for mining machinery to cope with the expansion in production. Open-pit mines (see Fig. 1) require digging machines such as large hydraulic excavators and transport machines such as dump trucks to excavate and transport the overburden (material above the ore) and ore. These machines in turn require a high capacity to improve their productivity by excavating and transporting large quantities of overburden and ore in a short time together with high reliability to avoid shutdowns for maintenance or due to sudden faults or other problems.

In the case of large hydraulic excavators, the requirements include producing larger excavators with bigger buckets to increase capacity and increasing the speed of mechanisms such as the front-end section and rotation mechanism to speed up the digging and loading process. As a single large hydraulic excavator can load five to 10 dump trucks, the failure of this one machine due to a trouble can bring a large number of dump trucks to a halt and shutdown production. What is needed, then, are robust designs that are not prone to faults and a maintenance program that replaces important parts before major faults occur that cause the machine to shut down.

In the case of dump trucks, the need is for improvements such as making the individual trucks larger so they can carry heavier loads and to increase the size of their tray, and better driving performance including up-hill speed and acceleration and deceleration. In terms of preventing breakdowns, the requirements are the same as for large hydraulic excavators.

With the rapid rise in the price of the diesel fuel used by these machines, and with maintenance being a major component of mine operating costs, other demands include better fuel consumption and to reduce the time and expense of maintenance.

This article describes ultra large hydraulic excavators and dump trucks for large open-pit mines.

Fig. 1—Open-pit Mine.
The requirements are for high reliability and a large capacity that can excavate and transport large quantities of overburden and ore in a short time.

ULTRA LARGE HYDRAULIC EXCAVATORS

The development of Hitachi Construction Machinery's ultra large hydraulic mining excavators has spanned more than 25 years, starting with the UH50 (8.4-m^3 loading shovel, 157 t) which went on sale in 1979 and followed by a series of larger models culminating in 2005's EX8000 (40-m^3 loading shovel, 811 t). The current product range consists of five models from the EX1900-6 to the EX8000-6 (see Table 1 and Fig. 2) which boast the leading share of the open-pit mining market thanks to their high capacity and excellent reliability.

In addition to outstanding capacity and reliability, Hitachi Construction Machinery hydraulic excavators also take account of the environment. Regardless of where in the world they are used, all of the ultra large hydraulic excavators are fitted with engines that comply with the North American tier 2 exhaust emission regulations of the US Environmental Protection Agency[1] (EPA).

TABLE 1. Specifications of Five EX Series Models
The specifications of the five models in the EX series of loading excavators are listed.

	EX1900-6	EX2500-6	EX3600-6	EX5500-6	EX8000-6
Capacity when used as loader (t)	191	249	361	522	811
Capacity when used as back hoe (t)	192	248	359	522	–
Engine	Cummins				
	QSKTA38	QSKTA50	QSKTA60	QSKTA50	QSKTA60
Rated engine output (kW)	810	1,007	1,450	2 × 1,007	2 × 1,450
Loader bucket capacity (m^3)	11	15	21	27	40
Back hoe bucket capacity (m^3)	12	15	22	29	–

Fig. 2—EX8000.
An EX8000 ultra large hydraulic mining excavator is shown.

Fig. 3—EX5500 Electric Excavator and EH4500 Dump Truck.
EX5500 electric excavator and EH4500 dump truck in use in Zambia are shown.

The product range also includes electrically operated models that have a three-phase induction motor in place of an engine[2] to further reduce the impact on the environment. Although electric hydraulic excavators have a number of disadvantages due to their need for an external power supply, including the need for power distribution equipment and an inability to operate away from the power supply, their advantages include not only being better for the environment due to their not emitting any CO_2 (carbon dioxide) exhaust nor requiring consumables such as engine oil and filters, but also the lower cost of electricity compared to diesel and cheaper overhaul costs for electric drives compared to diesel engines. The growing concern for the environment and the jump in the price of fuel has brought inquiries about electric hydraulic excavators from all over the world in recent years. Hitachi Construction Machinery has delivered a total of fifty electric hydraulic excavators to destinations such as Zambia, Commonwealth of Independent States (CIS), China, and Thailand (see Fig. 3).

The main components of an electric hydraulic excavator are the electric motor and cubicle that are made by Hitachi, Ltd. The slip rings and high-tension power lines are supplied by Hitachi Cable, Ltd. and all other electric equipment is also procured from within Hitachi. All of these parts are made to special specifications that take account of the conditions in which hydraulic excavators are used and are designed for resistance to impact, heat, and dust. When an EX2500E-5 excavator designed for long-duration operation (eight years or 30,000 hours at the MaeMo mine in Thailand) was trialed to confirm the reliability

TABLE 2. Specifications of EX3500AC II and EH4000AC II
The specifications of the EX3500AC II and EH4000AC II large dump trucks are shown.

	EH3500AC II	EH4000AC II
Rated capacity (t)	168	222
Carrying capacity (m^3)	111	153
Empty weight (t)	141	162
Target vehicle weight (t)	309	384
Engine	Cummins QSKTA-50CE	Cummins QSKTA-60CE
Engine output (kW)	1,491	1,864
Length (m)	13.51	14.28
Width (m)	8.99	9.54
Height (m)	6.77	7.36
Maximum speed (km/h)	56	56
Tire size	37.00R57	46/90R57

of electrically operated machinery and then brought back for inspection, it was found that all of the equipment satisfied the design levels of reliability. The machine was also rated highly by the customer.

DUMP TRUCKS

Large dump trucks used in open-pit mines typically have a carrying capacity in the 150-t class or larger with the largest being the 370-t class. The truck drive systems can be broadly divided into mechanical drive with an automatic transmission and electric drive in which the engine drives a generator which powers the electric motor used for traction. Electric drive is currently becoming the predominant type because of its superior drive performance, ease of maintenance, and cost advantages made possible by rapid advances in inverter technology.

In the past, Hitachi Construction Machinery marketed the EH4500 (280-t class) and EH5000 (300-t class) dump trucks from its Canadian group company Hitachi Construction Truck Manufacturing Ltd. Subsequently, the center of development was shifted to Japan and the EH3500AC II (190-t class) dump truck fitted with Hitachi, Ltd.'s latest IGBT (insulated-gate bipolar transistor) AC (alternating current) drive system[3] was released in 2008, followed by another model in the same series, the EH4000AC II (220-t class), in November 2010. Table 2 lists the specifications of these two models and Fig. 4 and Fig. 5 show photographs. These trucks are used around the world in countries such as Australia, South Africa, USA, and Finland. Like the ultra large hydraulic excavators, their high level of driving performance and reliability mean that the trucks are being used in growing numbers at a growing number of sites.

With Hitachi, Ltd.'s extensive experience in the development of electric drive systems in fields such as railways where its products are widely used, the collaborative development of the AC electric drive system for dump trucks allowed Hitachi Construction Machinery to make the best possible match between the vehicle and its electric drive system, giving the trucks better productivity due to the resulting high level of driving and operational performance. The time and cost of maintenance has also been reduced by using electric drive system components that are reliable and easy to maintain. Hitachi Construction Machinery is also involved in the joint development with Hitachi, Ltd. and Hitachi Engineering & Services Co., Ltd. of trolley-assisted dump trucks in response

Fig. 4—EH3500AC II.
A 190-t-class dump truck with an IGBT-AC (insulated gate bipolar transistor—alternating current) drive is shown.

Fig. 5—EH4000AC II.
The EH4000AC II dump truck (220-t class) went on sale in November 2010 and is one of a series of models.

to the rapid rise in fuel prices in recent years and the need to reduce greenhouse gas emissions to help prevent global warming, with the first truck due to enter service in the fall of 2011 at a copper mine in Zambia in Africa.

USE OF INFORMATION TECHNOLOGY IN MINING MACHINERY

As has already mentioned, reliability is important because breakdowns that cause the ultra large hydraulic excavators and dump trucks used at mines to stop working have a large impact on production and maintenance is essential to keeping these machines operating. Accordingly, it is important that maintenance inspections are performed accurately and efficiently.

Hitachi Construction Machinery fits sensors to important equipment to monitor machinery use and status and analyzes the resulting sensor signal data to identify faults and determine operating conditions. It also fits DLUs (data logging units) to the machines to collect records. Some of this data including operating time and fault history information is collected via satellite on global e-service servers (see Fig. 6) so that Hitachi Construction Machinery and its agents can monitor vehicle operation and provide advice.

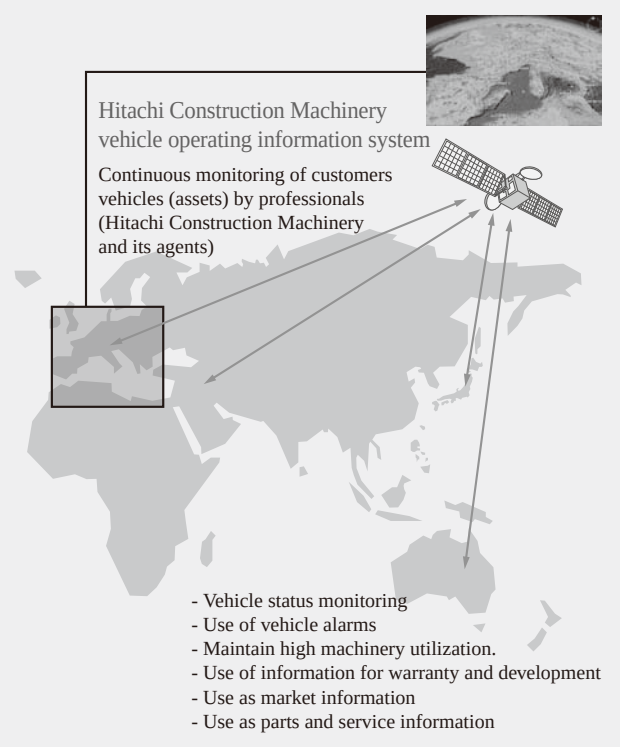

Fig. 6—Overview of Global e-Service.
Global e-service collects operating time, fault history, and other data for uses such as development and user support.

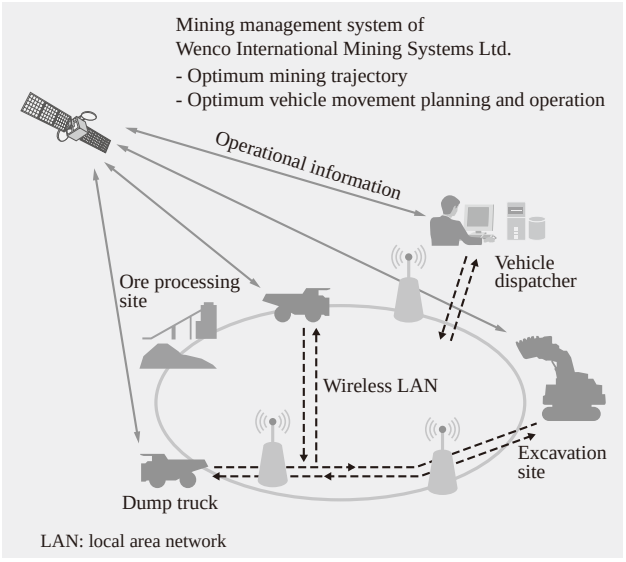

Fig. 7—Overview of Operation Management System.
The system provides efficient operational management with a realtime indication of vehicle operating status.

Also, detailed data collected by the DLUs can be downloaded to a PC (personal computer) and uploaded to global e-service to allow MIC[4] (machine information center) mining of this data to obtain detailed information about the machine and to allow remote assistance to be provided when troubleshooting in the event of a fault.

On the other hand, demand is emerging from large mines to provide efficient operation management systems that help improve productivity by monitoring the operating conditions for vehicles such as hydraulic excavators and dump trucks in realtime. Hitachi Construction Machinery acquired Wenco International Mining Systems Ltd., a Canadian mine operations management system company to establish the capability to supply operation management systems under its own brand. For the future, Hitachi Construction Machinery is seeking to expand the potential of the mining equipment business by combining the accurate preventive maintenance services it has provided through its existing global e-service with Wenco's operation management systems both to provide information analysis and other services that help improve productivity and cut costs and also to utilize operational data in areas such as the development of future models (see Fig. 7).

CONCLUSIONS

This article has described ultra large hydraulic excavators and dump trucks for large open-pit mines.

With the growth in the world's demand for resources expected to continue for some time, mine operators are looking for further efficiency improvements. In addition to developing machinery that reduces the burden on the environment while also improving performance and reliability and reducing running costs, Hitachi Construction Machinery intends to promote the adoption of IT (information technology) and respond to customer needs with total solutions.

Hitachi Construction Machinery will also continue to draw on group synergies and take an active approach to adopting technologies suitable for use in construction machinery from within the group to facilitate the development of machines and systems that Hitachi Construction Machinery Co., Ltd. would find difficult to develop on its own.

REFERENCES

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