Introduction of Product

Introduction of Large Wheel Loader WA600-6

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An environmentally friendly large wheel loader model WA600-6 that achieves both "Dantotsu" productivity and economy has been developed and has been introduced to its market. The background for the product development and technology incorporated in the new product, as well as the product itself, are described.

Key Words: *WA600-6, wheel loader, EPA tier-3 exhaust gas regulation, EU tier-3 exhaust gas regulation, EU Stage 2 noise regulation, "Dantotsu," low fuel consumption, vehicle classification, modulated clutch, lock up clutch*

1. Introduction

Since it was introduced to its market in 1995, the WA600-3 has won a high reputation among users in various fields. However, more than ten years have passed since the last model changes and a review has become necessary reflecting changes in user needs and model changes of competing machines.

Activities have been undertaken to meet social regulations such as Tier-3 exhaust gas regulation to be enforced in Japan, the USA and Europe beginning 2006 and EU Stage 2 noise regulation, as well as calls for global environment protection including reduction of CO_2 emissions to prevent global warming and for the respect of humans.

Against this backdrop, the WA600-6 has been introduced to a market, incorporating state-of-the-art technology for safety and environmental friendliness and for achieving both "Dantotsu" productivity and economy.

Photo 1 WA600-6

2. Aims of Development

The demand for dump trucks for operation in mines and quarries, where the WA600-class dump trucks serve, is changing from the 32-ton class to the 46-ton class. To meet this trend, the model changes has increased the bucket capacity and loading height to upgrade vehicle classification.

The development objectives were set as shown in **Table 1**, making new technologies a selling point based on Komatsu's basic concepts - "Economy, safety, environmental friendliness and IT." Emphasis was placed on making fuel consumption a selling point of "Dantotsu."

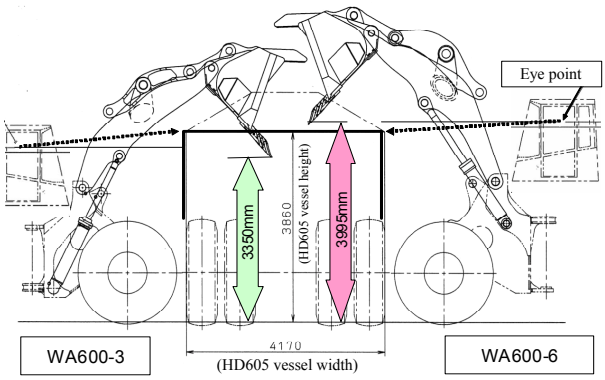
Table 1 Development aims and means to accomplish them

	Objective	Means to accomplish
Economy	Increase work rate	Upgrade vehicle classification: Dump trucks: 32 - 40 tons upgraded to 46 - 60 tons └ Increased bucket capacity and dumping clearance
	Low fuel consumption	Large-capacity torque converter + low revolution, high torque engine Variable capacity piston pump + CLSS (work equipment, steering circuit) Engine output 2-mode system (Modes P and E) Automatic gear shift point 2-mode system (Modes H and L) Lock up clutch torque converter installed as standard specification
Safety	Operator fatigue mitigation	Steering operation —— AJSS (reduced change frequency) Work equipment operation ┬ EPC lever (reduced stroke and operation force) └ Remote setting of bucket height and cutting edge angle Gear shift operation —— Automatic transmission Brake operation —— Left brake interlock modulated clutch Dwelling space —— Low noise, high airtight, large cab
	Enhanced visibility	High mount cab ROPS - monoblock large cab + rear heated glass
	Easy getting on/off out of cab	Rear access ladder + step light
Environment	Compliance with next-tier exhaust gas regulation (Japan, USA, Europe)	ecot3 engine
	Compliance with EU Stage 2 noise regulation	Variable displacement piston pump + hybrid fan Engine room sound-insulating construction
	Reduction of hazardous substances	Aluminum radiator, CO_2 reduction through improved fuel economy
IT	Easy trouble diagnosis	EMMS
	Easy preventive maintenance	VHMS (option)
	Energy saving drive guidance	Eco indicator

3. Principal Features

3.1 Upgraded vehicle classification

The vehicle classification has been upgraded to allow loading onto up to a 60-ton class dump truck with a standard boom and bucket to meet the demand trend for dump trucks. Compared with existing machine, the operator eye point height has been increased to allow viewing of the inside of the vessel during loading (**Fig. 1**).



Model No.		WA600-6		WA600-3	
Boom type		3850 mm boom	3990 mm boom	Standard boom	High lift boom
Bucket capacity (m³)		7.0	6.5	6.0	5.6
Bucket type		Pointed lip, shank and side guard equipped		Pointed lip and shank equipped	
Normal load (tons)		12.60	11.68	10.80	10.08
Dumping clearance (cutting edge) (mm)		3730	3995	3350	3995
Truck	Vessel height (mm)	Loading operations onto dump truck			
	HD605 class 3860	–	5	–	6
	HD465 class 3600	4	4~5	–	5
	HD405 class 3430	3	4	–	4
	HD325 class 3200	3	3	3~4	4

"–" indicates loading not permitted due to short dumping clearance

Fig. 1 Matching with dump truck

3.2 Environmentally friendly

(1) Low fuel consumption

The following five features are adopted as means to reduce fuel consumption.

1) A high fuel efficiency region of the engine can now be used by a match between the low-revolution, high-torque engine and the large-capacity torque converter (**Fig. 2**). By adopting the large-capacity torque converter, the absorption torque is increased at low-revolution, thereby reducing excessive stepping onto the accelerator pedal on start and during digging. This reduces fuel consumption.

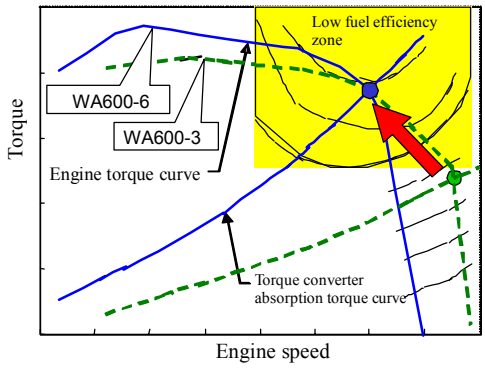


Fig. 2 Match between engine and torque converter

2) Hydrau MIND system

The newly developed Hydrau MIND system (variable capacity piston pump + CLSS [closed-circuit load-sensing system]) is adopted in the work equipment and steering circuit, drastically reducing hydraulic pressure losses compared with the conventional fixed-capacity pump system. A function to cut the flow rate and relief when the boom is raised beyond a horizontal position is provided with work equipment to further reduce the load (**Fig. 3**).

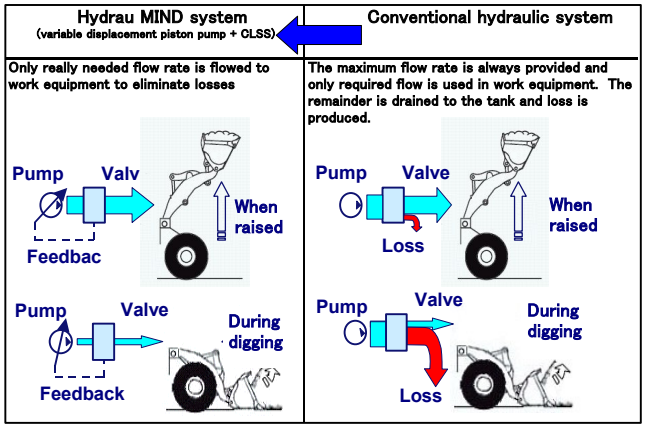


Fig. 3 Comparison of Hydrau MIND system and conventional hydraulic system

3) Duel mode power select system

A system to allow the selection of engine output from two modes (Modes P and E) is adopted.

The WA600-6 is tuned to minimize fuel consumption while securing a sufficient work rate in most work types, departing from the conventional concept of Mode E (**Fig. 4**). To accomplish this, the momentary type is adopted for the mode selection switch so that Mode E is always set when the engine is restarted. Mode P is selected when productivity is a concern.

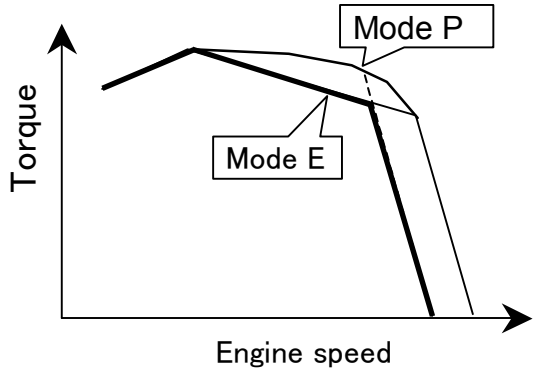


Fig. 4 Engine torque curve (Modes P and E)

4) Selection of two automatic transmission gear shift points (Modes H and L)

In loading and carrying work and driving a long distance, two automatic transmission gear shifts can be selected tuned to the grade of the road. Mode L is selected on a flat road for shifting at a low travel speed, to maintain the engine at a low revolution speed and to achieve high fuel economy.

5) Torque converter with lock up clutch

This torque converter is a standard specification to drastically save fuel consumption in uphill traveling over a long distance. The conventional lock up clutch functions only in the maximum gear shift. The torque converter functions beginning in the 2nd gear to make a greater contribution to fuel economy (**Fig. 5**).

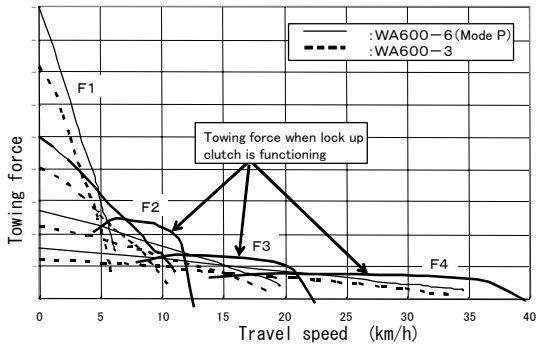


Fig. 5 Towing performance

As a result of the aforementioned methods are adopted, these features have enhanced fuel economy more than 20% in V-shape loading, which is typical work, compared with a conventional machine (**Table 2**).

Table 2 Comparison of fuel consumption with conventional model *

Work type	Item		WA600-6		WA600-3
			Mode E	Mode P	
V-shape loading	Fuel economy	ton/L	127	124	100
	Fuel consumption	L/h	89	98	100
	Work rate	ton/h	113	121	100

*) In-house test data. Data with WA600-3 indicated as 100.
In actual work, it differs depending on the conditions and work type.

(2) Low noise

Exterior noise is reduced by reducing the rated revolutions (10% reduction compared with a conventional machine), by shielding the engine room and by installing a variable displacement piston pump, to comply with the EU Stage 2 noise regulation. A rise in the heat-balance temperature as a tradeoff is solved by reducing hydraulic pressure losses through various controls and by increasing airflow with a hybrid fan. These measures have controlled the heat-balance temperature to lower than that of a conventional machine, enhancing the heat-resistance reliability of the equipment.

(3) Exhaust gas regulation

The Tier-3 exhaust gas regulation is complied with without deteriorating fuel economy by installing the “ecot3” engine, Komatsu’s state-of-the-art technology. The principal changes are as follows.

- The fuel injection system has been changed from the conventional HPI (high-pressure injection) system to the common rail system of electronically controlled high-pressure injection, enabling fuel injection of a higher degree of freedom.
- Equipped with a cooled EGR (exhaust gas recirculation) system to lower the combustion temperature to curb the generation of NOx.
- Fuel combustion simulation calculations were made to set a special shape for the combustion chamber. Optimization of combustion with electronically controlled combustion and injection has reduced emissions and enhanced fuel economy.

3.3 Comfortability and Controllability

(1) Reduction of operator noise

The cab sound insulation property and air tightness have been enhanced through sealing property of the floor ducts for wire harnesses and through pipes and window-opening and -closing construction, in addition to the cab viscous mount and rubber mounts of the hydraulic piping and valves. Noise has been reduced by 6dB (A) compared with a conventional machine.

(2) Adoption of automatic transmission of all-stage electronic modulation system

To reduce shocks and time lags in frequent forward and backward traveling and gear shift operations thereby ensuring tireless operation over a long time, automatic transmission of the all-stage electronic modulation system is adopted. A learning control function is provided to maintain the clutch piston chamber-filling time constant to prevent variation over time of the modulation characteristics due to wear of the clutch discs.

(3) Large armrests with adjusting mechanism

Operator fatigue of the wheel loader is high because work is performed while the entire vehicle moves and travel speed is high. Requests are often received for improvement of the operator’s seat in large wheel loaders with which work is performed for a long time.

To meet these user requests, a large seat of the air suspension type equipped with large armrests featuring an adjusting mechanism has been adopted. The armrests can be adjusted freely longitudinally and vertically and their angle can also be adjusted (**Fig. 6**).

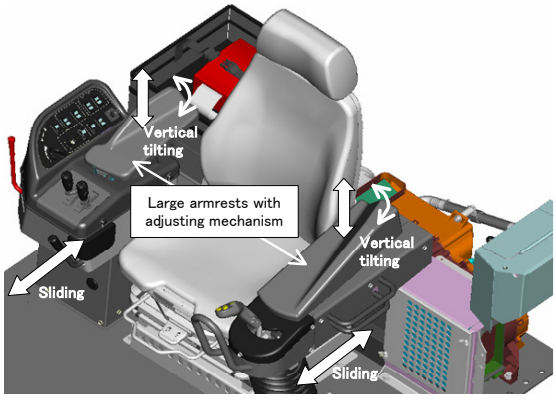


Fig. 6 Large armrests with adjusting mechanism

(4) Modulated clutch interlocking to left brake

Modulated clutches have already been adopted in the WA1200-3 for control of the towing force and travel speed. Interlocking with the left brake pedal, the mechanism allows inching. Compared with the conventional transmission cut-off system, the new mechanism eases travel speed adjustment when approaching the dump truck and allows high-efficiency work (**Fig. 7**).

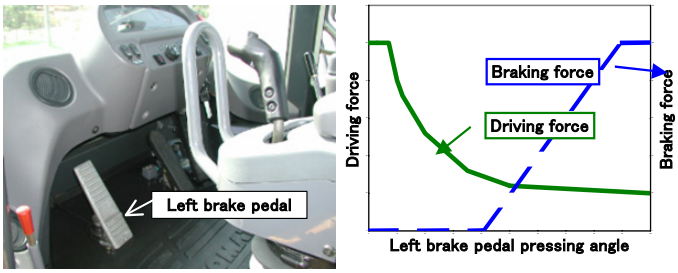


Fig. 7 Driving force and braking force when left brake pedal is pressed down

(5) EPC (electric pilot control) work equipment lever

Compared with the conventional PPC work equipment lever, the EPC lever reduces the control force to 60% and stroke to 75% to mitigate fatigue in work over a long time. The following electronically controlled functions further enable ease of work (**Fig. 8**).

1) Remote boom positioner function

The high- and low-limit positions of the boom height can be set freely from the cab, eliminating problems of boom positioning.

2) Remote bucket angle positioner function

The bucket angle during digging can be fixed within a range of about ±5° on a monitor operating in the cab so that the bucket angle can be set optimally in accordance with the material to be dug (**Fig. 8**).

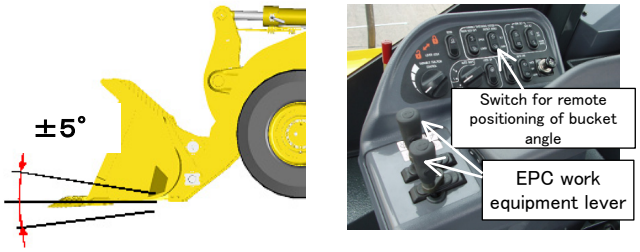


Fig. 8 EPC lever and remote bucket positioner

3) Semi-automatic digging function (Option)

Digging operation of the bucket can be automated so that simultaneous operation of the boom lever and bucket lever can be eliminated, allowing easy operation of work equipment during digging even by unskilled operators. The bucket operation pattern can be selected from “loose” for loose materials and “rock” for blasted rock depending on the material handled.

(6) AJSS (Advanced Joystick Steering System)

Compared with conventional electric joysticks of the speed control type, AJSS is of a position control type similar to the steering wheel type, resulting in fewer operations and without a feeling of discomfort (**Fig. 9**). This system has been adopted in super-large wheel loaders (WA700 or higher) and is highly appraised because of fatigue mitigation in work over a long time. The WA600-6 has been tuned to further improve straight travel and shocks during steering in reverse, to further enhance the controllability. The joystick lever has more dents on the forward and backward switch operation part and the grip has a larger diameter than conventional type to better fit the hand (**Photo 2**).

(AJSS is available in some areas as an option.)

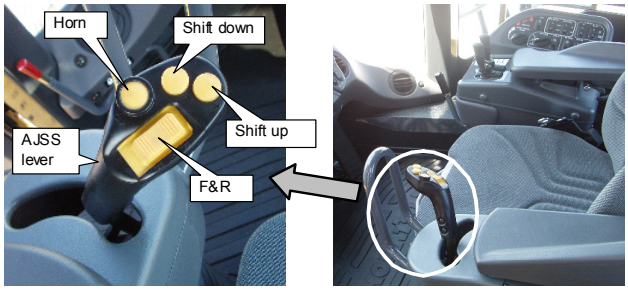


Photo 2 AJSS lever

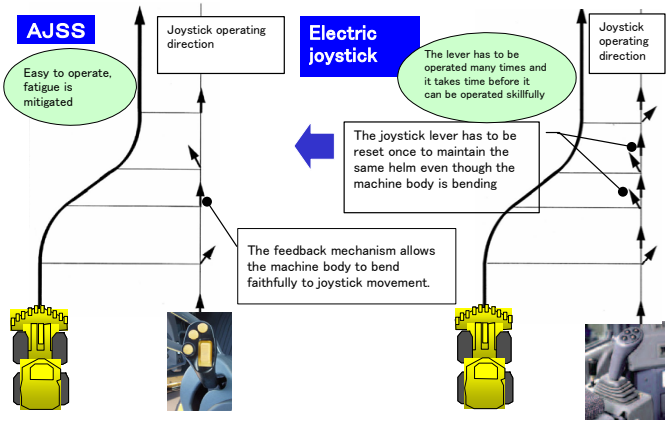


Fig. 9 Comparison of AJSS and electric joysticks

3.4 Enhanced Safety

(1) Adoption of large ROPS cab

A large ROPS cab, 16% wider than conventional cabs, is installed to provide a dwelling space allowing even an operator of large build to operate easily. The front side of the loader has a larger glass area compared with conventional machines to ensure good upward and downward visibility.

The rear of the cab has heated glass for easy cleaning of fog and frost on the glass for better rear visibility.

(2) Rear access ladder

For easy getting into and getting out of the cab, a rear access ladder is adopted. A step light is installed atop the cab to ensure safety when getting into and getting out of the cab at night (**Photo 3**).

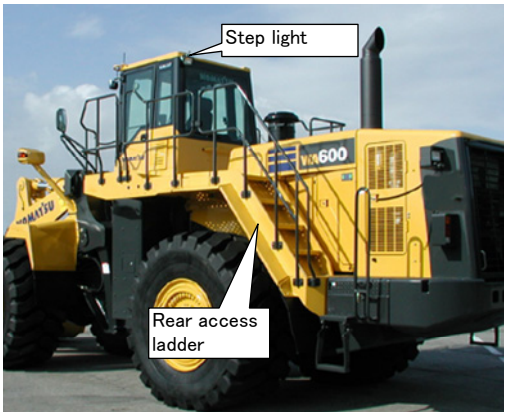


Photo 3 Rear access ladder

3.5 IT Features

(1) EMMS (Equipment Management Monitoring System)

The monitor panel has a trouble diagnosis function and maintenance management function, displaying a failure code for a failure and machine maintenance status on a character display installed at the center bottom of the main monitor as necessary.

Design of the water thermometer, torque converter oil thermometer and other gauges has been changed entirely compared with that of gauges in conventional types as better visibility is needed with large machines. An eco indicator is installed inside the monitor panel, indicating the level of braking force onto the accelerator pedal by green lamps (**Photo 4**).

Photo 4 Eco indicator

When VHMS (Vehicle Health Monitoring System) is installed, the operating frequency of this eco indicator and fuel consumption data are presented to the operation center for use in the operation guidance of operators.

(2) VHMS (option)

VHMS (Vehicle Health Monitoring System) for preventive maintenance is available as an option for ease of trouble diagnosis and vehicle management. The VHMS controller controls the principal components of the vehicle and centrally manages various controllers in real time. Data of the controllers are downloaded to a personal computer and are continuously followed for use in preventive maintenance in dealing with vehicle failures and other events. When a satellite communication function is installed, vehicle information can be obtained in real time by WebCARE.

3.6 Enhanced Reliability and Durability

(1) Bushing of work equipment

Well proved bushings of carburized multiple-grooved that have been installed in super-large loaders higher than WA700 are adopted to ensure the formation of an oil film in the sliding parts of the bushings. Oil-sealed pins are adopted in bucket hinges for automatic greasing (option) to enhance reliability and to minimize maintenance servicing.

(2) Variable traction control system

The sliding rate of the modulated clutch is varied by adjusting the dial inside the right console, allowing free setting of the maximum towing force of the 1st gear between 20 and 100% (**Fig. 10**). Especially at sites where the road surface is slippery, this function curbs the maximum towing force in advance to prevent the cutting of tires caused by slipping.

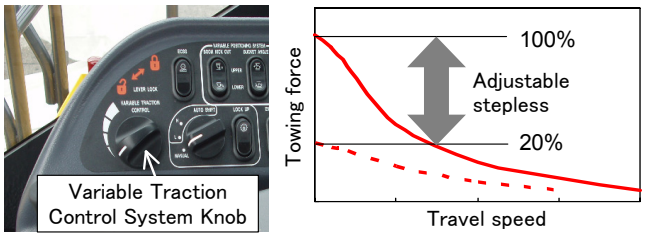


Fig. 10 Variable traction control

(3) Large bucket tire guard

Large bucket tire guards are installed to prevent cutting of the tires by running onto large boulders during earth digging (**Fig. 11**).

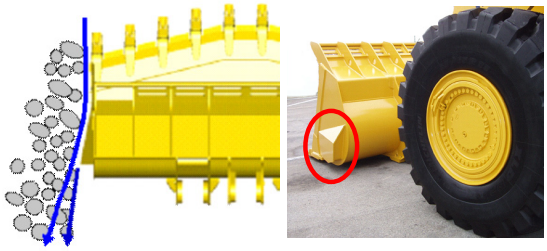


Fig. 11 Large bucket tire guard

3.7 Enhanced Maintainability

(1) Modular radiator cores

The radiator cores are split into modular cores. When a core is repaired, only the needed part is taken out without removing the radiator guard (**Fig. 12**).

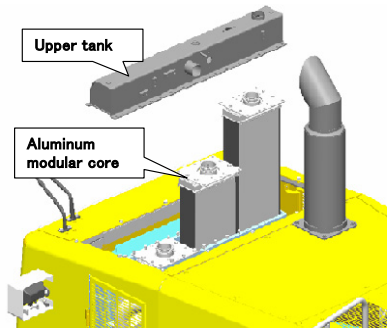


Fig. 12 Modular radiator core

(2) Hydraulic driven fan

A reverse-rotation fan function is used to periodically blow off foreign materials clogged in the radiator cores. In maintenance servicing, the cores are cleaned from the inside also by high-pressure blowing. The mount bracket of the hydraulic driven fan is of a swing type so that the cores can be cleaned easily by removing the fan net.

4. Conclusion

In the development work, the most painstaking tasks were fuel economy without lowering the work rate and maintenance of a comfortable operational environment for operators. The WA600-6 has already been put on the market sequentially beginning with markets outside Japan. Fortunately, users have evaluated the model highly and efforts made in undertaking the model changes are being rewarded.

Market information will be followed more promptly and carefully to smoothly introduce new products in the future.

Introduction of the writer

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[A few words from the writer]

Komatsu manufactures principal components in house such as engines, power trains, hydraulic equipment and controllers. The writers strongly felt the strength of in-house manufacturing when this model changes was tackled. Although the quality goal that was like a higher hurdle had been set, the goal was somehow achieved by working along in development as a whole.