Introduction of Products

Hydraulic Excavator Model PC300-10

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Focusing on the "Environment," "Safety" and "ICT (infocommunication technology)" as concepts, a medium hydraulic excavator model PC300-10 has been developed and launched on the market. The technologies incorporated in the same are described and the product is introduced.

Key Words: *Environment, Safety, ICT, Reduction in Fuel Consumption, ECO Guidance, ID Key*

1. Introduction

In recent years, the importance of reducing CO_2 and other environmentally burdensome substances has been increasing. Accordingly, Tier4 Interim emission regulation has been enforced in Japan, the United States and Europe since 2011.

Against this backdrop, the development of the PC300-10 was undertaken to meet the new regulation, be environmentally friendly, warrant customer benefits and reduce fuel consumption.

During this development effort, the vectors of establishing new technology for the machine body and developing components, including engine and hydraulic equipment, were made as part of the major goal of reduction in fuel consumption. The PC300-10 outlined in the following is set for imminent market launch (See **Figs. 1** and **2**).

Fig. 1 PC360LC-10 (North American specification)
(Source: In-house material.)

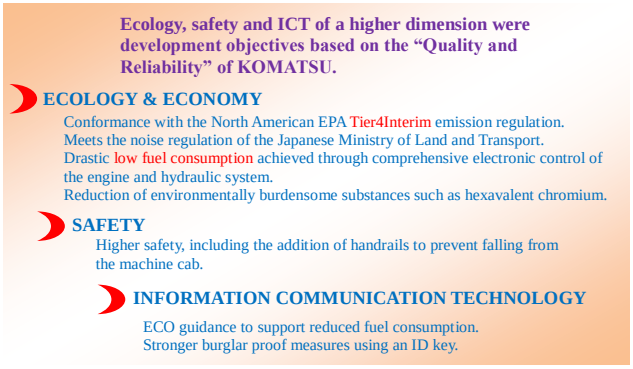

Fig. 2 Development concept (Source: In-house material)

2. Development Objectives

The development concepts of the PC300-10 were "Ecology," "Safety" and "ICT (Information Communication Technology)" of a higher dimension based on "Quality and Reliability" original to KOMATSU. Incorporating this concept, the product power was significantly enhanced by meeting new environmental regulation, reducing environmentally burdensome substances, ensuring safety and utilizing ICT technology as overviewed in the following, which describes the related characteristics:

1) Ecology
   - · Conformance with the Tier4 Interim emission regulation of Japan, the United States and Europe
   - · Reduction in fuel consumption of 10% compared with a current Komatsu model
     (Comparison of average work patterns based on KOMTRAX analysis)
   - · Support by ECO guidance reduces fuel consumption
   - · Reduction of environmentally burdensome substances
   - · Conformance with the noise regulation of the Japanese Ministry of Land and Transport and EU Tier2 noise regulation

2) Safety

The following features were added compared with current models to develop a global machine featuring a safety design, which conforms to strict global safety standards, and offers comfortability.

   - · Handrails to prevent falling from the machine cab
   - · Engine shutdown secondary switch
   - · Seat belt alarm
   - · Battery disconnect switch

3) ICT
   - · More robust burglar proof measure using an ID key
   - · More content in KOMTRAX report items

4) Enhanced work performance
   - · Higher traction force by increasing the capacity of the travel motor

3. Selling Points

Elaborating on these items, the selling points of the PC300-10 and means and technologies to accomplish them are described in the following:

3.1 Ecology

3.1.1 Conformance with emission regulation

To meet the Tier4 Interim emission regulation of Japan, the United States and Europe, the regional emission regulation and regulation enforcement years for PC300 class machines are summarized in **Table 1**.

Table 1 Tier4 Interim emission regulation
(Source: In-house material)

Regulatory values: Nox/HC/PM, *(NOx+NMHC)/PM (g/kW·h)

	Tier3 Regulation		**Tier4 Regulation**	
	Regulatory timeframe	Regulatory value	Regulatory timeframe	Regulatory value
Japan	Oct. 2007 ~	3.6/0.4/0.17	Oct. 2011 ~	2.0/0.19/0.02
USA	Jan. 2007 ~	*4.0/0.20	Jan. 2011 ~	2.0/0.19/0.02
Europe	Jan. 2007 ~	*4.0/0.20	Jan. 2011 ~	2.0/0.19/0.025

The new engine technologies incorporated in the PC300-10 to meet the foregoing exhaust gas regulation are listed below (**Fig. 3**).

- · PM Post-Processing Device
  The new Komatsu Diesel Particulate Filter (KDPF) was developed to drastically reduce particulate matter (PM) in exhaust gases.
- · Variable Turbocharger
  The new Komatsu Variable Geometry Turbo (KVGT) achieves low emissions, low fuel consumption value and good response.
- · Cooled EGR (Exhaust Gas Recirculation) and high-efficiency EGR cooler
  The combustion temperature is effectively lowered by an EGR valve of the hydraulic servo mechanism, evolving from hydraulic drive which has proven viable in medium and large Komatsu engines and by a high-efficiency EGR cooler, thereby helping further reduce NOx and fuel consumption.
- · Komatsu Closed Crankcase Ventilation (KCCV) ventilator
  Emissions of blowby gas were reduced to zero by reducing the level of blowby gas into the intake circuit through the KCCV ventilator.
- · Others
  Reductions in NOx, PM and fuel consumption were achieved by increasing the injection pressure of the electronically controlled high pressure fuel injection system (HPCR - High Pressure Common Rail) used in current models to 180 MPa and further optimizing the combustion chamber shape. Collaboration among the improved engine controller (CM2250), additional new sensors and actuator allows precision control of the EGR ratio, fuel injection and post-processing device, meeting the new NRTC (Non-Road Transient Cycle) regulation.

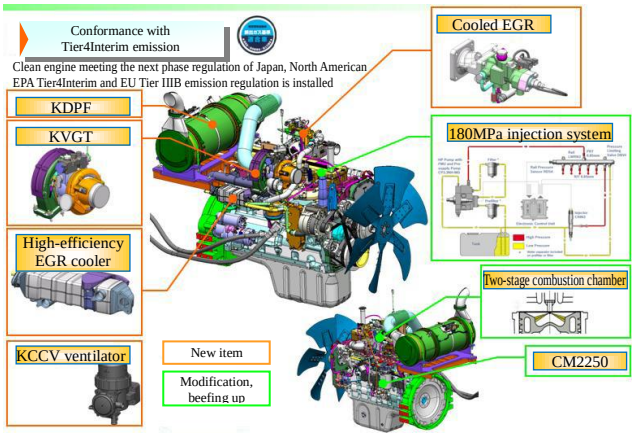

Fig. 3 New technologies incorporated in the new engine (Source: In-house data)

3.1.2 Reduction in Fuel Consumption

1) Improvement in engine fuel consumption efficiency

Incorporating the foregoing new engine technologies has allowed conformance with the Tier4 Interim emission regulation and a drastic improvement in the engine fuel consumption efficiency (fuel consumption map).

Comparing the light and medium load regions by the same horsepower, the engine fuel consumption map shows that the lower the engine speed, the more economical the fuel consumption efficiency (**Fig. 4**).

Utilizing this characteristic, more efficient fuel consumption was achieved through the machine control described in 2).

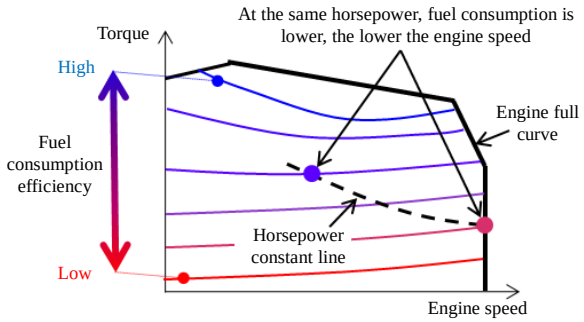

Fig. 4 Conceptual diagram of the engine fuel consumption map

2) New matching control of the engine and pump

"New matching control of the engine and pump" represents a technology to sense the conditions of the pump and engine by various sensors and lower the engine speed as far as possible after ensuring the necessary and adequate pump discharge (**Figs. 5** and **6**). The matching control used in the PC228US-8 was refined through a low engine speed in accordance with the operation pattern, through higher precision achieved by a control that restrains dispersions and through other means.

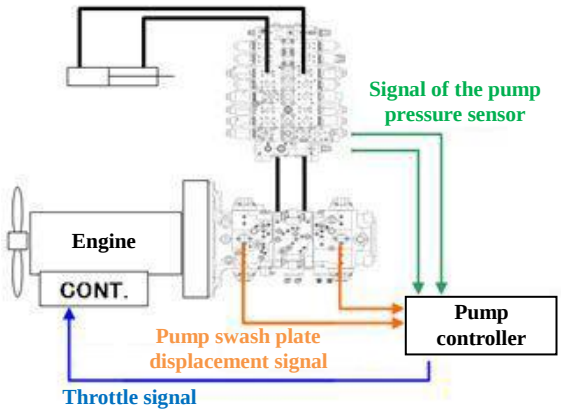

Fig. 5 New matching control system for the engine and pump (Source: In-house material)

Model / Work	PC300-8	Fuel consump-tion	PC300-10
Heavy load (large pump discharge)	Released quantity; Engine speed; Engine; Hydraulic pumps	=	
Light load (small pump discharge)	Adjustment is made by pump swash plate depending on the necessary pump discharge.	>	Engine speed decreases automatically depending on the necessary pump discharge.

Fig. 6 New matching control of the engine and pump

The combination of this matching control, drastic improvement of the fuel consumption map and characteristic of the fuel consumption map whereby the lower the engine speed, the more the fuel consumption efficiency rises, is in the light to medium load region mentioned in 1), where an increase in the fuel consumption efficiency was effectively achieved. For example, a conceptual diagram in **Fig. 7** shows changes in engine speed and fuel consumption during 90° swing, digging and loading work when this matching control is utilized.

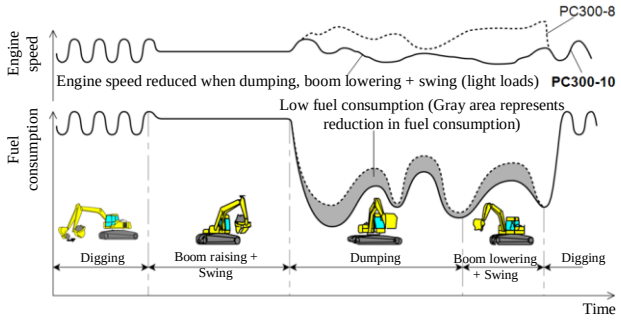

Fig. 7 Conceptual diagram of changes in engine speed and fuel consumption in new matching control of the engine and pump

Additionally, by lowering the engine speed, both fan horsepower and noise were reduced.

3) Smaller oil pressure loss during swing operation

Large torque and high pressure are needed during acceleration in swing. Oil is relieved through the safety valve of the swing motor to ensure this pressure and the relief flow rate at this time becomes a loss (**Fig. 8**).

To mitigate this problem, a control was devised whereby the safety valve of the swing motor was changed to a type allowing the opening of the valve to change to two levels and the safety valve setting was raised during acceleration to secure pressure while the discharge flow rate of the pump was reduced. This reduced the relief loss during acceleration in swing and fuel consumption.

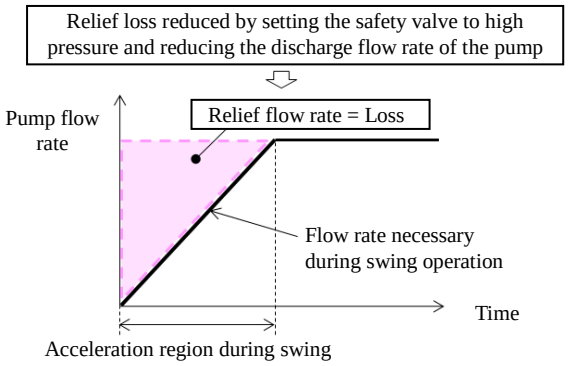

Fig. 8 Reduction in oil pressure during turning

4) Reduction in oil pressure loss in back pressure

Back pressure is introduced into the drain circuit using a lift check valve to prevent negative pressure of actuators such as cylinders and motors. Previously, the pressure setting for back pressure was stationary. However, a control scheme was designed to vary the pressure setting so that the required back pressure could be introduced in accordance with actuator motion and reduced when there was no risk of negative pressure. This control scheme reduced the oil pressure loss of back pressure.

5) Low auto-deceleration speed

Fuel consumption was reduced by further lowering the deceleration speed when the lever is in NEUTRAL position (**Fig. 9**).

Item \ Model	PC300-8	PC300-10
Low idle speed (rpm)	1000	1000
Deceleration speed (rpm)	1400	**1000**

Fig. 9 Auto-deceleration speed

6) Other fuel consumption reduction technologies

Merge-divider control of the oil pressure incorporated in the PC200-8 and other models and reduction of pressure loss in the hydraulic circuits, including the main valve, helped reduce fuel consumption.

The low fuel consumption technologies described in 1) to 6) significantly reduced fuel consumption. The increase in efficiency made possible by the reduction of oil pressure losses (= increase in production) helps reduce fuel consumption by controlling the engine output for the same production with increased high efficiency.

The real fuel consumption in the average work pattern by KOMTRAX analysis represents a 10% reduction compared with a current machine and during 90° swing, digging and loading work in Mode P of the KOMTRAX panel, -13% compared with a current machine (production equivalent to a current machine).

3.1.3 Eco guidance

A function to display operational advice on the multi-monitor is included to efficiently operate the machine and restrain unnecessary fuel consumption. If an operational state suits a condition, various advice messages are displayed on the multi-monitor (**Fig. 10**). Items related to fuel consumption reduction and the conditions and purposes displayed in advice messages are listed below.

1) Deterrence on oil pressure relief

A message is displayed if an unnecessary oil pressure relief operation is performed. Unnecessary oil pressure is restrained.

2) E Mode is recommended

This message is displayed if light-load work is continued in P and ATT/P modes. E Mode is used during light-load work to save fuel consumption.

3) Partial travel is recommended

This message is displayed when a machine travels many hours with the setting of travel speed adjustment Hi.

The engine throttle dial is turned to the low side to save fuel consumption.

4) Idle stop is recommended

This message is displayed if the levers are not operated for an extended period.

Fuel consumption during unnecessary idle is restrained.

A function to display the average fuel consumption is also added in addition to the ECO gauge displayed on current machines.

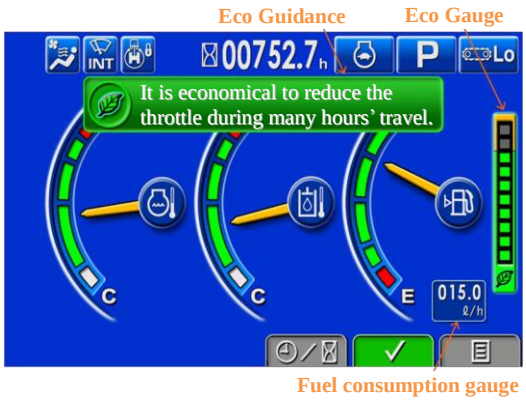

Fig. 10 Example of the ECO guidance display (Source: In-house material)

Functions to display the following items have also been added:

- An operation records screen that shows the working hours, idling hours and other items (**Fig. 11**)
- An ECO guidance records screen showing the number of displays of each ECO guidance (Operational advice messages are also displayed similarly) (**Fig. 12**)
- A screen to display the history of average fuel consumption per hour and the average fuel consumption per day (**Fig. 13**)

Displaying these screens in real-time to the operator allows him/her to be more conscious of fuel consumption, thereby facilitating efficient machine operation, maintenance and management as well as the maintenance and management function for conventional machines.

Fig. 11 Operation record screen (Source: In-house material)

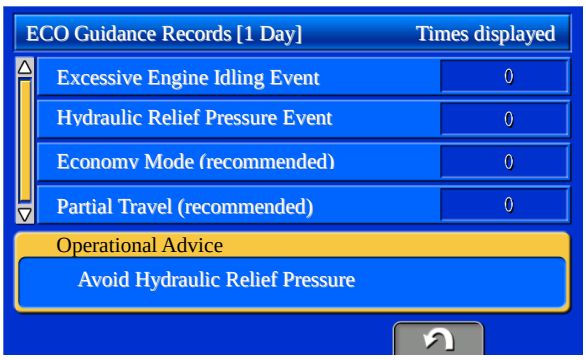

Fig. 12 ECO guidance record screen (Source: In-house material)

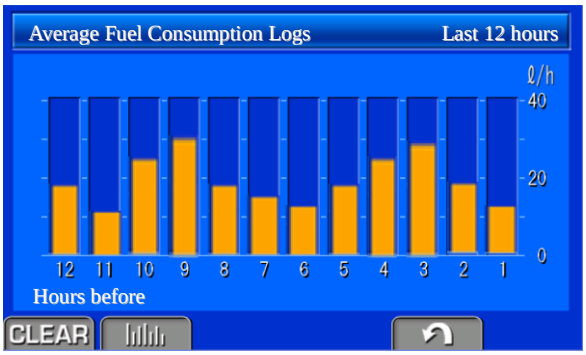

Fig. 13 Average fuel consumption logs screen (the figure shows average fuel consumption per hour) (Source: In-house material)

3.1.4 Reduction of environmentally burdensome substances

An effort to reduce fuel consumption was made using the foregoing fuel-consumption reduction technologies and CO_2 emissions were significantly reduced. In addition to CO_2 emission reductions, reductions of other environmentally burdensome substances could be achieved, including the cessation of use of hexavalent chromium.

3.1.5 Conformance to noise regulation

As in current machines, the noise regulation of the Japanese Ministry of Land and Transport and EU Tier2 noise regulation were met. A major contribution to a reduction in engine speed was made by new matching control of the engine and pump as mentioned earlier, via a cooling shroud that reduces the sound of the rotating fan blades and the optimum layout of sound absorbing materials in meeting the regulation.

3.2 Safety

Safety has been further enhanced by adding the following devices to the conventional safety and comfortable design:

3.2.1 Handrails to prevent falling from the machine cab

Handrails to prevent falling from the machine cab have been added, meeting the new standard under ISO 2867 (**Fig. 14**). The machine structure design eliminates the need to walk on the counterweight during engine maintenance,

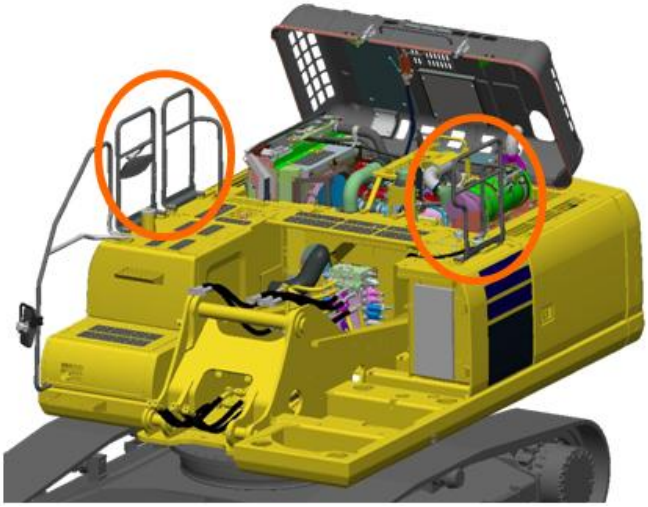

Fig. 14 Handrails to prevent falling from the machine cab (Source: In-house material)

3.2.2 Engine shutdown secondary switch

An engine shutdown secondary switch has been newly installed under the operation seat for use in an emergency (**Fig. 15**).

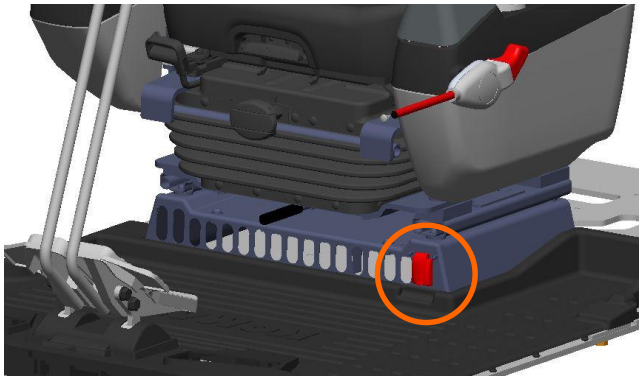

Fig. 15 Engine shutdown secondary switch (Source: In-house material)

3.2.3 Seat belt alarm

An alarm lamp lights up on the top left of the monitor screen when the operator has not yet fastened the seat belt (**Fig. 16**).

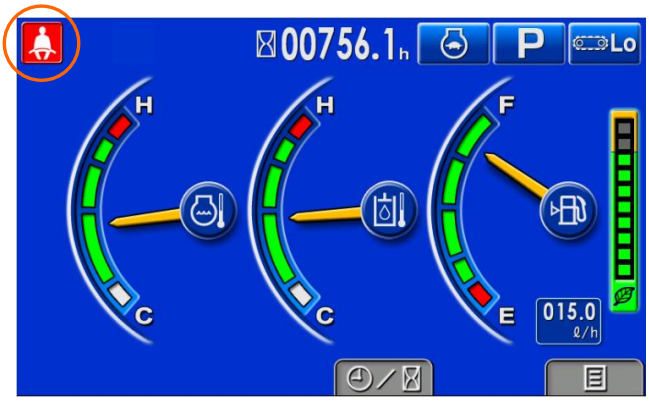

Fig. 16 Seat belt alarm (Source: In-house material)

3.2.4 Battery disconnect switch

A battery disconnect switch is installed as a standard specification item to enhance safety during maintenance of the electric circuits (**Fig. 17**).

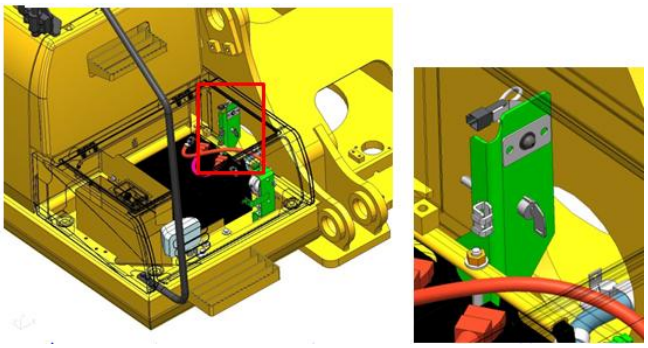

Fig. 17 Battery disconnect switch (Source: In-house material)

3.3 ICT

3.3.1 ID key

The ID key is a system that manages the engine start by reading the key ID using an ID key antenna located near the key insertion slot and electronically collating the read ID using an ID key controller to decide whether or not the ID is authentic (**Fig. 18**). This function reinforces the burglar proof quality.

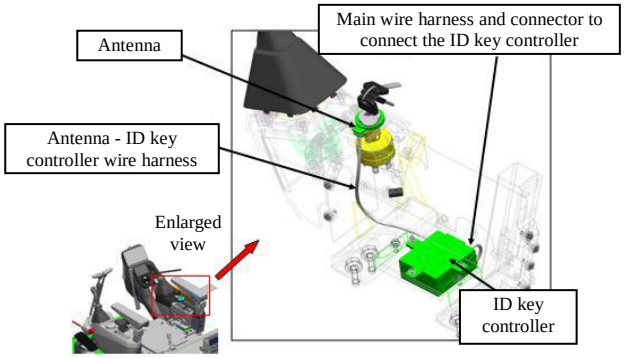

Fig. 18 Overview of the ID key (Source: In-house material)

3.3.2 Enhanced functions of KOMTRAX

In addition to the items reported by KOMTRAX previously, advice on reduction in fuel consumption is described to input more information into the report (**Fig. 19**).

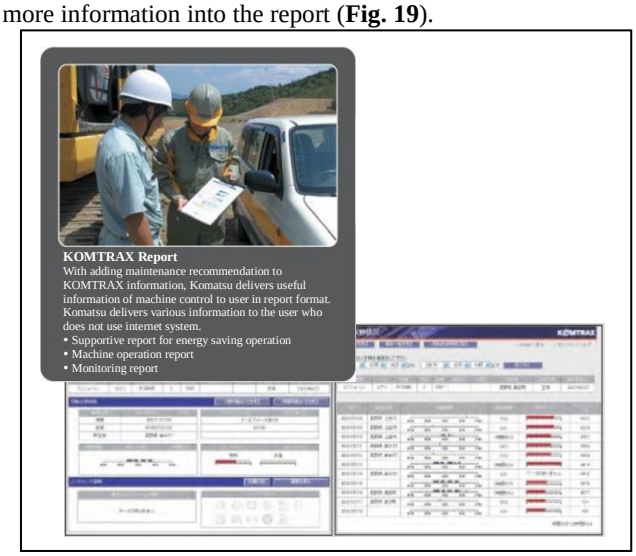

Fig. 19 More content in the KOMTRAX report (Source: In-house material)

3.3.3 New large color multi-monitor

The visibility and screen resolution of the conventional 7-inch large TFT (Thin Film Transistor) liquid crystal panel have been further improved by using a high-definition liquid crystal panel. The monitor is multilingual and the desired language can be selected from a total of 25.

3.4 Enhanced Travel Performance

3.4.1 Stronger traction force

A new travel motor with increased capacity has been installed to increase the traction force by 10% compared with a current machine. Despite the increased travel motor capacity, the fuel consumption during travel is identical to that of current machines without deterioration compared with current machines, by incorporating the foregoing fuel consumption reduction technologies.

4. Conclusion

The PC300 series is one of the mainstay products, representing the core elements of medium-sized Komatsu hydraulic excavators. Fuel-consumption reduction technologies could be established in this development work thanks to cooperation among the research, development and quality verification departments. Featuring various selling points, including conformance to regulation and reduced fuel consumption, the product will be deployed sequentially in markets, beginning with North America, Europe and Japan. It is hoped that the product will win high market acclaim.

Introduction of the writers

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[A few words from the writers]

After undergoing various quality verification processes, the product could be refined as envisioned in the concept. A high product evaluation can be expected in the markets.