

Introduction of Products

Introduction of Komatsu's New Hydraulic Excavator PC200-7 in GALEO Series

Yuuichi Iwamoto

We accomplished the development of new hydraulic excavators of the medium class that have embodied various design concepts like an IT technology, safety and global environment, basic performance, etc. Named hydraulic excavators in GALEO Series, the new machines have been introduced in the world markets with success. This paper takes up one of them, PC200-7, as a sample to explain the background of the development, the technology that sustains the design concepts and features of the product.

Key Words: GALEO, Basic Performance, Comfortability, Global Environment, Safety, IT, Versatility, Maintenance

1. Background of Development

Over the past several years, the Komatsu's PC200 hydraulic excavators gradually ceased to be a general-purpose machine in the Japan's market and were changing its role to a dedicated machine in a big construction site where hydraulic excavators did not need to be sensitive to the movement of their rear end due to a limited site space. They owe this change to PC228 US, a short tail hydraulic excavator that has become the de-facto standard model of this class in the market thanks to its high competitiveness and therefore marketability. In the foreign markets, PC200 hydraulic excavators still remain to be a general-purpose machine, presumably because short tail hydraulic excavators are yet to permeate in the market. Even so, customers in the foreign markets have filed with us a number of varied requests for change based on their

applications different from those in our domestic market. Generally, hydraulic excavators of PC200 class are the best selling machines in each market, accounting for a larger portion of the population, as a result of which the competition has been drastically intensified. For this reason, it was required of us to assure viability of both dedicated PC200 for large construction and short-tailed PC228US in each segmented market, while maintaining versatility of PC200 as a general-purpose machine and to satisfy the requirements from overseas customers. (See Fig. 1) It was against such a backdrop of the markets and requirements from the customers that the old PC200 has been completely model-changed for the first time in nine years and a new look PC200-7 in GALEO Series has been developed and made debut in the markets. (See Photo 1)

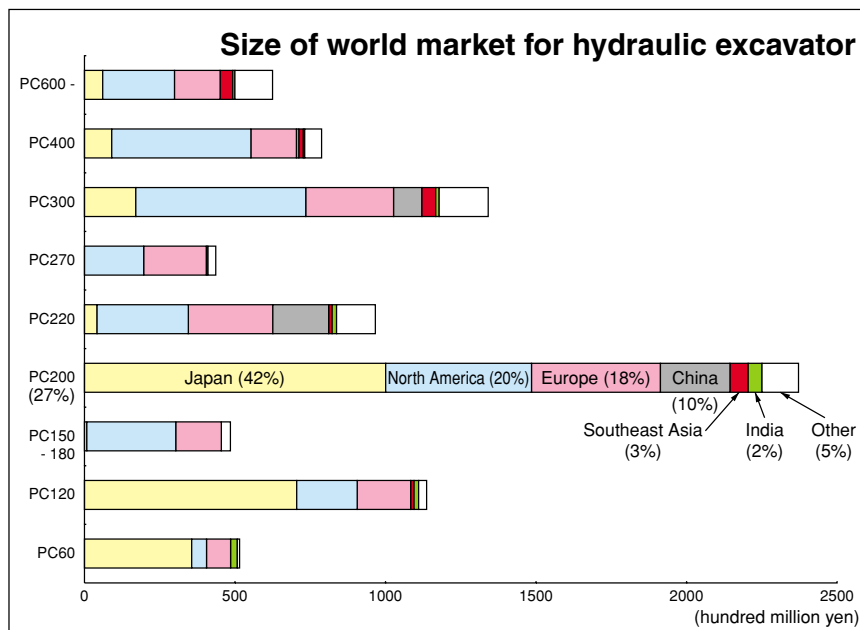


Fig. 1 World Market for Hydraulic Excavator



Photo 1 PC200-7 in GALEO Series

2. Concept of PC200-7 as commodity

Prior to starting the designing, we decided that a uniform brand name of our new generation construction and mining equipment be called “GALEO Series” that are to be applied across all the models, and that new machines embody the following machine concepts. (See Fig. 2)

- (1) To provide our customers with solutions to their problems through making the most of available IT (Information Technology)
- (2) To help alleviate the environmental burden on the earth
- (3) To help establish safer working environment
- (4) To provide high basic performance and quality of machine that are tenable worldwide

Those concepts were further developed into the following seven items of concepts for new hydraulic excavators in GALEO Series. (See Fig. 3)

- (1) **Basic performance**
To establish compatibility a large production and low fuel consumption
- (2) **Comfortability**
To assure a comfortable environment in the operator's cab with a low noise level and little vibration
- (3) **Global environment**
To mount an engine of clean gas emission and low noises
- (4) **Safety**
To clear safety standard in each country
- (5) **IT**
To equip new machines with KOMTRAX and EMMS
- (6) **Versatility**
To equip new machines with a multi-color monitor having multiple functions
- (7) **Maintenance**
To facilitate the maintenance work and extend an interval of periodic machine maintenance

Komatsu's Brand for New-Generation Construction and Mining Equipment

Genuine Answers for Land & Environment Optimization

GALEO is derived from the following words:
 Galea = Helmet* (Latin)
 Geo = Earth (Greek)
 Leo = Lion (Latin)

* The source of the term "galea" is the helmet worn by Minerva, the Roman goddess of wisdom and art.

Fig. 2 GALEO Brand

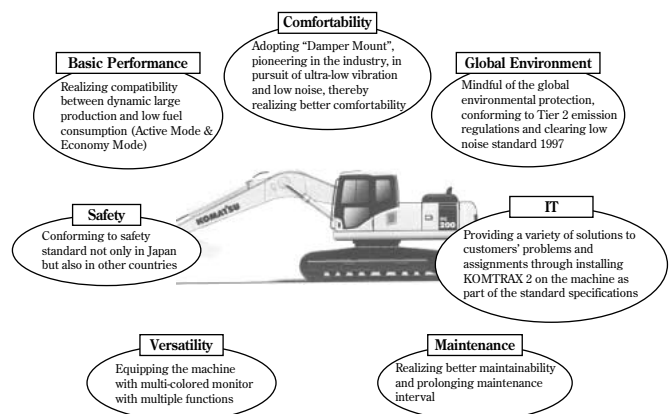


Fig. 3 Concept of PC200-7 in GALEO Series

3. Sales Features

Here let us discuss sales features and the technology that supports them in the order of the seven items of concept for new hydraulic excavators in GALEO Series.

3.1 Basic performance

This means to achieve compatibility between a large production and a low fuel consumption; to improve the machine's basic capability by enhancing the safety and widening the application range; and to attain high reliability by heightening the structural strength.

- (1) A newly developed Komatsu's SAA6D102E engine was mounted on the new PC200-7 machine to allow it to acquire a higher output and a lower fuel consumption. As a result, a higher horsepower of 145 PS was obtained as against 135 PS of its precursor PC200-6. In addition, an air-cooled aftercooler was newly adopted, which accomplished a lower fuel consumption through improving the combustion efficiency. (See Fig. 4)

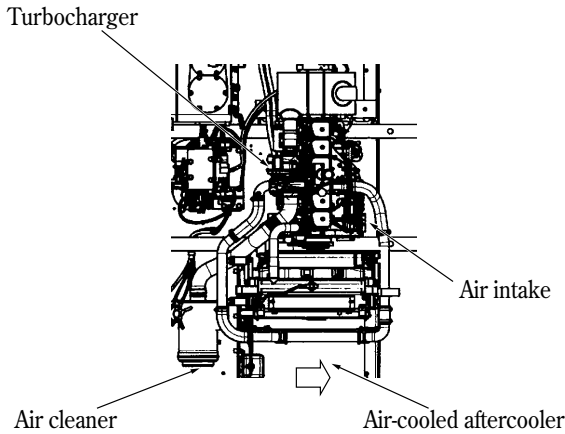


Fig. 4 Air-cooled Aftercooler

- (2) To make a large amount of work compatible with low fuel consumption, two modes are prepared in the fuel selector; Active Mode to enable the maximum amount of work and Economy Mode to ensure a good fuel consumption. With Active Mode, the engine and the fuel pump are controlled in such way that the engine can exert the max. horsepower of 145 PS constantly. This is an increase of 8% in terms of production as compared with that of PC200-6. The two-mode fuel selector system has also succeeded in keeping the fuel consumption to the level of the engine on the preceding PC200-6 through eliminating losses in the hydraulic circuit and the engine output. With Economy Mode, on the other hand, an area of the best

fuel combustion is used by lowering the engine revolution by 200 rpm. This practice has brought about 10% reduction in the fuel consumption, while maintaining the same production, as compared with the preceding PC200-6. (See Fig. 5)

- (3) The bucket digging force has been brought up by 10% to realize speedy and dynamic operation of the machine. Moreover, the bucket digging force has also been increased by 17%. This increase in turn contributes to raising the digging power that is measured with a formula of "Speed × Force". Meanwhile, the arm digging force has been increased by 11%, too. Incidentally, a one-touch power max. switch was one of the main features of the forerunning PC200-6, which enables the machine to exert a high power at a critical moment of digging. This useful function has been employed in the new machine, too.
- (4) As an essential element for still enhancing the machine's working efficiency, machine stability has been increased as much as 15% as compared with PC200-6, which has led to the operator's feeling of higher stability when digging and higher efficiency in the lifting work. Now operators used to harbor a desire to reach out to a still higher point with the arm equipped with an attachment. This desire came true as the max. digging height of 10 meter was realized. (See Fig. 6)

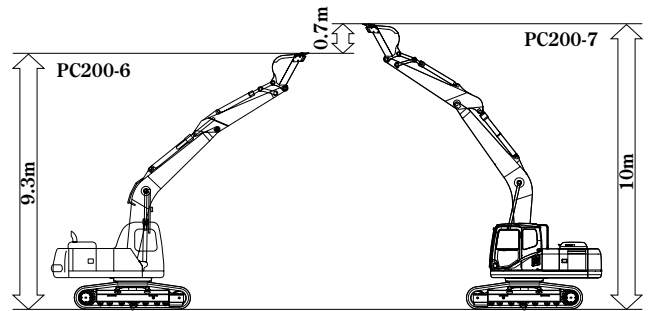


Fig. 6 Increased Max. Digging Height

| | Production (index) | Fuel consumption (index) | Fuel efficiency (index) |
|-------------------------|--------------------|--------------------------|-------------------------|
| Active Mode PC200-7 | 108 | 100 | 108 |
| Active Mode PC200-6 | 100 | 100 | 100 |
| Economy Mode PC200-7 | 92 | 80 | 116 |
| Heavy-duty Mode PC200-6 | 95 | 92 | 103 |

Fig. 5 Production as Contrasted with Fuel Consumption

(5) To ensure the machine's reliability commensurate with the increased working efficiency, the strength of the work equipment had to be increased. Regarding the improvement of the boom, a cast iron-made boss on the top of the boom cylinder has been upsized to enable it to receive stress in a wider area, since stress concentrates on that portion of the boom cylinder. At the same time, thickness of the cylinder wall was increased to boost its section rigidity. (See Fig. 7)

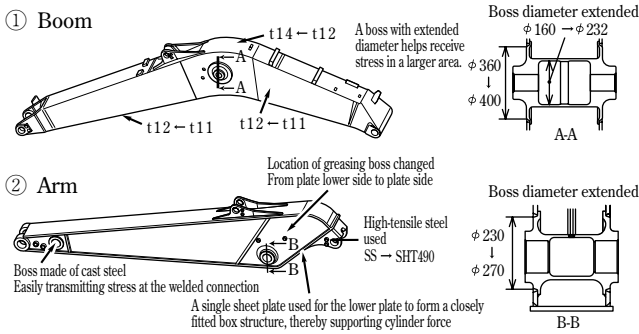


Fig. 7 Strengthened Work Equipment

(6) In pursuit of longer durability of the undercarriage, meanwhile, a strut has been added to the track links; square nuts have been adopted; and the record-proven grease lubricated pins have been again adopted. (See Fig. 8)

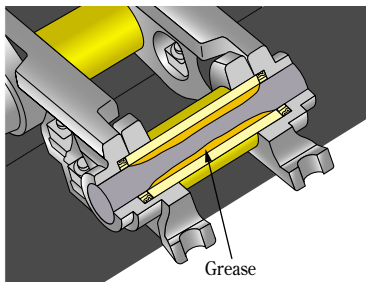
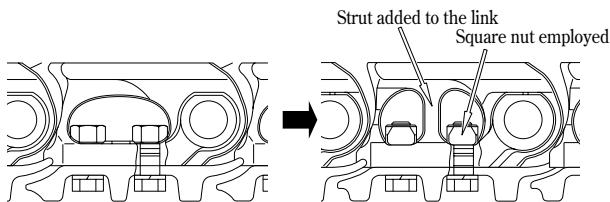


Fig. 8 Strengthened Undercarriage

3.2 Comfortability

This means to provide an operator with a comfortable working station in the form of a spacious, quiet and air-conditioned operator's cab.

(1) The design of an operator's cab has been changed with the aim of providing enough inner space for big operators in the West. As a result, its volume has been increased as much as 14% as compared with the operator's cab for PC200-6. In addition to this change, an adjustment amount of reclining angle of the operator's seat and an adjustment amount of fore and aft tilting angle of the console have been enlarged, all these being designed to provide any operator of any size with the optimum angle to fit his or her physique. Another design change made on the operator's cab is that the doorway has been widened to make getting in and out of the cab easier. (See Photo 2.)

Cab volume

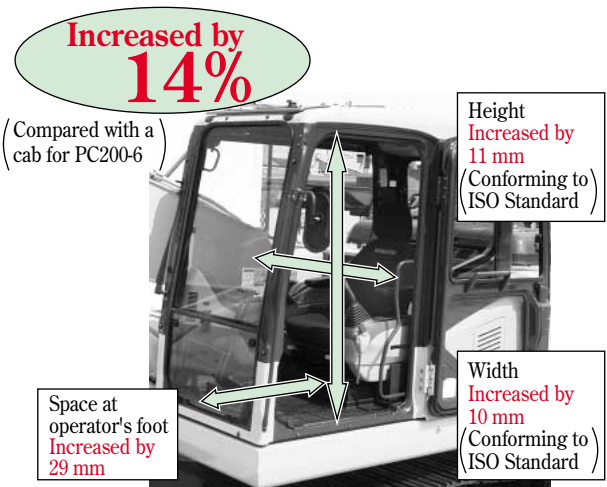


Photo. 2 Enlarged Operator's Cab

(2) For the purpose of preventing vibration from the chassis from being transmitted to the cab interior, PC200-6 had adopted a multi-layer viscous mount. Although it succeeded to drastically improve operators' comfort, we developed and adopted a damper mount for PC200-7, which is a notch more advanced than the multi-layer viscous mount. This new mount receives vibrations in the up and down direction with a spring instead of the conventional rubber. It absorbs vibrations more effectively owing to the reduction in spring constant and the longer stroke. (See Fig. 9)

| | Measurement Item | Riding on obstacle with one track shoe / Forward at Hi speed |
|---|---|--|
| <p>Multi-layer viscous mount</p> | <ul style="list-style-type: none"> • Cab center pillar left and right vibration (rattling of cab) • Cab floor up and down vibration (operator's riding comfort) | <p>+2.6g -2.8g -2.8g -7.8g</p> |
| <p>Damper mount</p> | <ul style="list-style-type: none"> • Cab center pillar left and right vibration (rattling of cab) • Cab floor up and down vibration (operator's riding comfort) | <p>±1.4g +2.3g -3.4g</p> |

Fig. 9 Cab Damper

(3) For the purpose of realizing fewer vibrations in the cab interior, the height of a deck supporting the operator's cab has been raised to the level of that on PC300-6, and thickness of the structural materials has been increased to enhance their rigidity to lower the vibrations transmitted to the revolving frame. For realizing lower noises in the cab interior, meanwhile, a noise absorbing material has been fitted to the deck below the cab, which fills clearance in between. Entry of noises transmitted through air into the cab is thus prevented. (See Fig. 10)

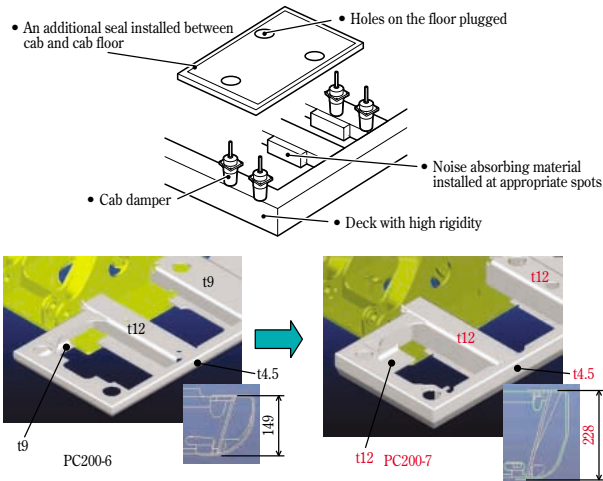


Fig. 10 Measures for Lowering Noise from Deck and Cab Floor

(4) Another feature about the operator's cab is an adoption of a large capacity fully automated air conditioner as part of the standard specifications. Thanks to the device, an operator can enjoy the same comfortable operating environment throughout the year. The new air conditioner has increased its air tightness to prevent the entry of fine dusts. When it is set in the air intake mode, the air pressure level inside the cab clears 5 mmAq specified in the ISO Standard for pressurizing air to check entry of dusts from the outside. It is for the first time that an air conditioner of this class has conformed to the standard.

(5) The last improvements to introduce are that the operator's cab is newly equipped with a one-touch lock to facilitate opening and closing of the front window and an assist-pushup mechanism to lessen force needed when pushing up the front window; and that a pocket is provided behind the operator's seat for storing the detached lower window pane. Safely put in the space, it does not block the operator's view. (See Fig. 11)

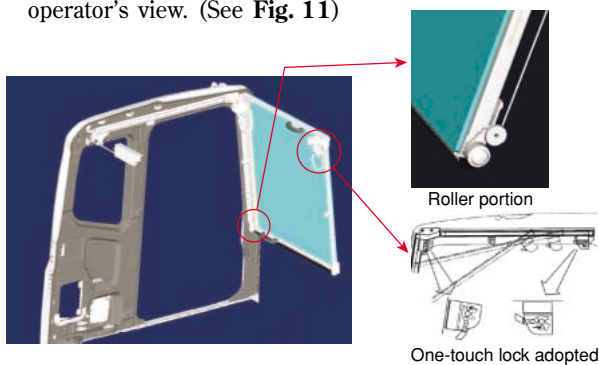


Fig. 11 Contrivance for Opening/Closing Front Window

3.3 Global environment

This means to mount engines that conform to the emission regulations (Tier 2) enforced in Japan, North America and Europe. As for ambient noises, the PC200-7 conforms to the low noise standard for 1977 set forth by The Ministry of Land, Infrastructure and Transport of Japan and the EU regulations for noise.

(1) Komatsu's engines have cleared the emission regulations (Tier 2) in Japan, North America and Europe well ahead of the mandatory enforcement date. The Tier 2 regulations prescribe further reduction in NOx and PM levels (particulate materials) than those in the Tier 1. (See Table 1.) Our response to this requirement has been to install a large capacity aftercooler which serves to lower the suction air temperature and to improve the fuel injection timing and the configuration of the combustion chamber. All these improvements combined, the NOx level has been lowered by 32% and the PM level by 21%.

Table 1 Summary of Tier 2 Emission Regulations

| | Tier 1 Regulations | | Tier 2 Regulations (draft) | |
|---------------|-------------------------------|-------------------|-------------------------------|-------------------|
| | Year of mandatory enforcement | Restriction value | Year of mandatory enforcement | Restriction value |
| Japan | 1997 | 9.2/- | 2003/10 Estimated | 6.0/0.30 |
| North America | 1997 | 9.2/- | 2003 | *6.6/0.30 |
| Europe | 1999 | 9.2/0.70 | 2003 | 6.0/0.30 |

*: NOx + NMHC

(2) Our approach to lowering the ambient noises was to first combat a noise source and prevent generated noises from leaking out. To counter a noise at its source, a bell mouth shroud has been adopted, which is useful to bring down a wind-cutting noise caused by engine fan revolution. To reduce noises from the engine itself, noise absorbing or shut-off materials have been used. Meanwhile, an adoption of a large capacity and large swing motor has helped lower hydraulic as well as mechanical noises generated at the time of swing. Furthermore, the doors of exterior parts adopted a structure of dual sheet plates lined with noise absorbing material. Thanks to all these improvements, the PC200-7 has successfully attained 102 dB(A) sound power level as against 106 dB(A) stipulated in the noise level standard for 1997 by The Ministry of Land, Infrastructure and Transport. It has also conforms to the EU regulations.

(3) In Economy Mode of the fuel selector, the CO₂ gas emission amount has dropped by 20% compared with Active Mode, an achievement worth being called Environmental Mode.

- (4) The last innovation in this area is a change in the used materials in consideration of recycling afterwards. For noise absorbing material, polyethylene terephthalate is employed, which is a material used for manufacturing PET bottles. For a material covering the cab ceiling, Kenaf, a natural fiber, is used. Finally resin parts in use are all numbered. (See Fig. 12)

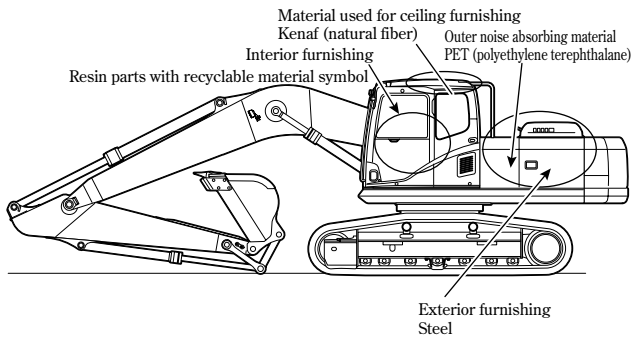


Fig. 12 Production Materials Keeping Recycling in Scope

3.4 Safety

This means an operator's cab with rigidity high enough to protect an operator inside and a chassis that conforms to the safety standard in every aspect of use like operation, maintenance and climbing up and down in every country where the machine is used.

- (1) The operator's cab is made of a strengthened frame that is molded in one piece by a press. It has an increased shock absorbing capability and excellent durability. It also conforms to the standard for head guards in the Japan's Industrial Safety and Health Law that is intended to protect an operator from a heavy falling object while inside a cab. The law says that a cab must withstand the impact without an additional guard being installed on the top. In addition, a top guard, which conforms to Level 2 of ISO OPG (Operator Protecting Guards), and a front full guard are also prepared as an add-on type optional attachment for a construction site like a quarry where there is a potentially big danger of falling objects. (See Fig. 13)

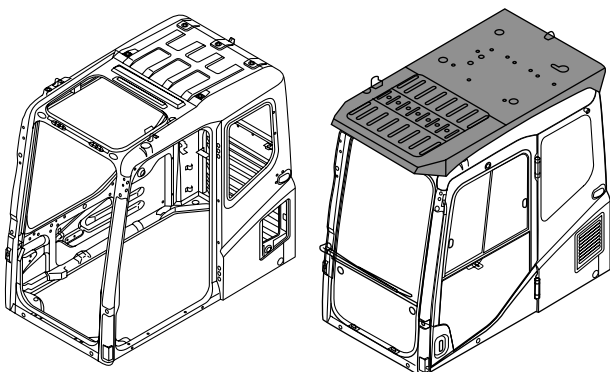


Fig. 13 Frame Structured Operator's Cab and Top Guard

- (2) The strengthened frame structure of the operator's cab has been reviewed with an aim of obtaining good visibility in mind. As a result, it was decided to change the section form of the frame instead of opting for a larger size, to dispose of a pillar on the center right and to configure a rear pillar so that it will not block the rear view. These efforts resulted in a 34% decrease in the dead angle due to pillars seen at an operator's eye level. (See Fig. 14)

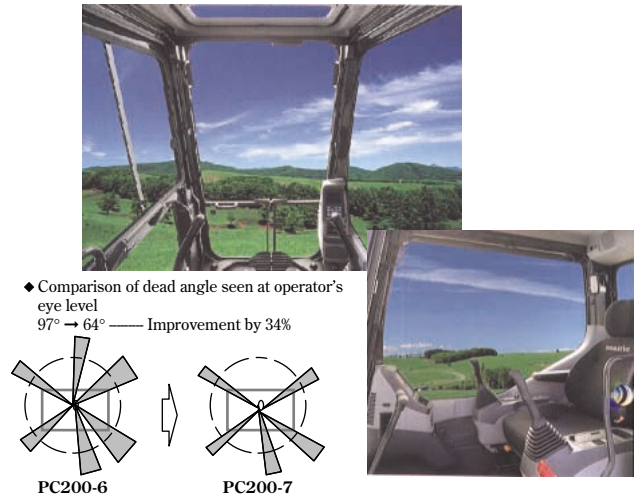


Fig. 14 Securing Better Visibility

- (3) A large capacity defroster, which satisfies the relevant ISO Standard, has been installed in the operator's cab in order to ensure good visibility all the time during the winter season when the front window easily gets cloudy.
- (4) The machine is so designed as to conform to the most stringent safety standard enforced in Japan, North America or Europe to protect an operator in every aspect of use such as climbing in and out of the cab, maintenance and inspection, not to mention operation of the machine. (See Fig. 15)

(4) EMMS (Equipment Management Monitoring System) stands for equipment management monitoring system. EMMS is installed on each machine to monitor its conditions and activities for the purpose of facilitating troubleshooting and speeding up repairs. If any abnormality is found in the machine during an inspection prior to the beginning of the day's work or during operation, that is displayed in the multi-monitor of EMMS to warn the operator. Moreover, an abnormality or failure occurred in the past is recorded and can be referenced as a history at the time of maintenance or repairs. It also memorizes a schedule for the maintenance service like a time for replacing the engine oil and announces when the time has come around. (See Fig. 17)

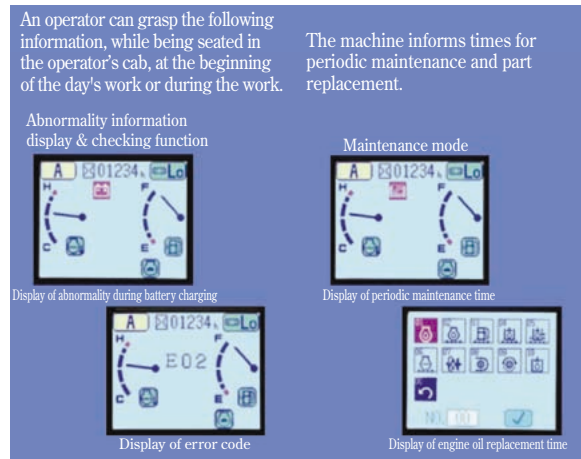


Fig. 17 EMMS

3.6 Versatility

This means to install a multi-colored monitor having multiple functions on a machine to facilitate man-machine interface like an easy control of attachments.

(1) The new machine is equipped with a liquid crystal multi-colored monitor which has drastically increased display information. It is expected to enhance its display intelligibility and to widen the versatility. Better intelligibility has been made possible with the standard display not only by using merely characters and symbol marks, but also enlarging their sizes and adopting various colors. An analog type engine cooling water temperature gauge, hydraulic oil temperature gauge and fuel gauge are arranged in series in the display. Now too bright a display is disturbing to the work at night. For this reason, the working lamp switch is so designed as to double as a display brightness selector switch, which allows an operator to select a display exclusively for the night. (See Fig. 18)

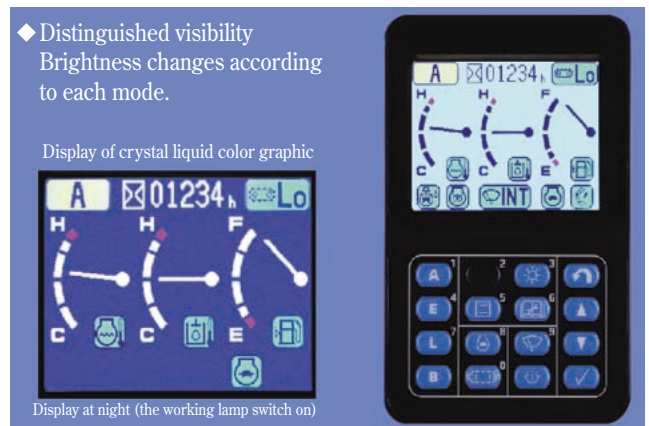


Fig. 18 Colored Multi-monitor

(2) It is required of a hydraulic excavator as a general-purpose machine to accommodate various kinds of attachments. In order to make it easier to install and operate them, the hydraulic circuit has been designed to switch to the double acting circuit in Active Mode and Economy Mode, while switching to the single acting circuit in Breaker Mode. The underlying idea is that in the former case, installing an attachment like a crusher is anticipated that is opened and closed by hydraulic oil going back and forth, and in the latter case, installing a breaker is anticipated that is operated by hydraulic oil switching on and off. In addition, in Breaker Mode, the relief pressure is kept lower than that of Active or Economy Mode and the hydraulic oil is conducted through a high performance hydraulic oil filter in the return circuit. These functions, i.e. switching to the lower relief pressure and passing the oil through the filter, is automatically activated whenever Active Mode or Breaker Mode is selected. In this connection, an operator can adjust the volume of hydraulic oil commensurate with each attachment, as he watches a display in the monitor. (See Fig. 19)

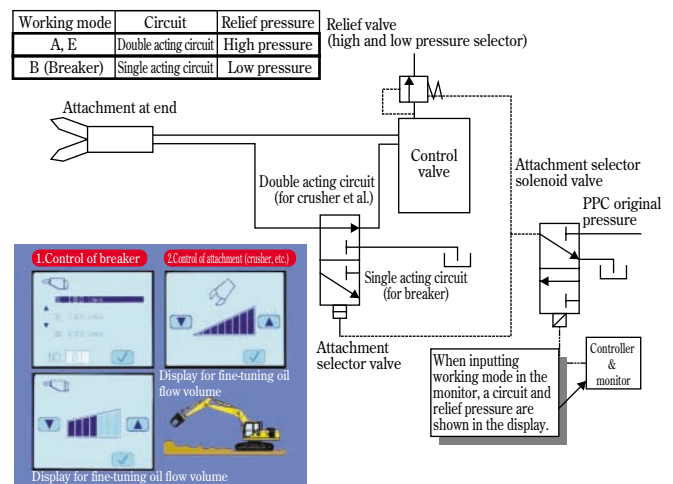


Fig. 19 Control of Attachment

- (3) When the machine is equipped with an arm crane and the operator selects Lifting Mode, a display in the monitor changes and instead shows displays concerning crane work like a net load and the rated load; a revolving warning lamp lights up; and the bucket stopping function is activated.
- (4) In order to prevent an unauthorized transport of the machine, a protective device is installed on the machine using this multi-monitor. That is, a password is inputted in the multi-monitor beforehand. When turning the engine starting key, a password input display appears on the monitor, and unless the correct password is inputted, the engine cannot be started. In that case, even if the engine is successfully started by short-circuiting the battery terminal and the engine starting motor, the machine is still immobilized. (See Fig. 20)

3.7 Maintenance

This means to prolong an interval for the periodic maintenance and to upgrade maintainability, thereby lowering the overall machine maintenance cost.

- (1) A greasing interval for the work equipment has been extended from every 250 hours of use up to every 500 hours of use. This extension has been accomplished through adopting a lubricant containing bushing, long lip dust seal for preventing entry of water and mud, resin-made shims to protect both end surfaces of the bushings and by thermally spraying tungsten carbide on the end surfaces of the arm tip and the bucket for better protection. (See Fig. 21) A replacement interval for the engine oil and engine oil filter has also been extended up to 500 hours of use. This extension was made possible with the use of a filtering material of high performance. Extension of the two intervals has eventually led to an extension of interval for periodic maintenance up to 500 hours of use. Overall, the maintenance cost has been cut back by approx. 30% as compared with that for PC200-6 machines.
- (2) The engine oil is likely to leak or seep at the time of replacement or thereafter. In an effort to ward off the oil leak, an eco-drain valve has been installed to the engine oil pan. Not only that, this innovative valve allows a one-touch connection with a dedicated automatic oil drain system. Now it can handle both draining and refilling,

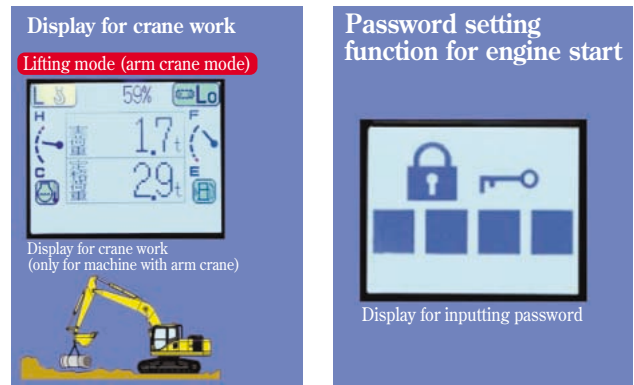


Fig. 20 Arm Crane and Password

which also led to the enhanced working efficiency in periodic inspections.

- (3) Another contrivance put in force is to have widened space between the radiator and the oil cooler for easier cleaning. In addition to that, single disassembly and installment of the radiator and the oil cooler alone are made possible to shorten a time required for repairs or replacement, should it happen.
- (4) For the manufacture of the fuel tank, plating steel sheet metal has been adopted to heighten rust prevention property of the interior wall. At the same time, the capacity has been increased by 18% to render it to be a large capacity tank, so that once it is refilled, it can last operation for a considerably long period. The fuel tank drain valve was moved to the right side of the door for an easier access. A water separator with a pre-filter is now provided in the fuel system as part of the standard specifications to prevent water and dust from entering the engine.
- (5) A washable floor mat with a slight slant toward the cab door is laid on the cab floor. It makes it easier to flush the floor and drain water. A drain hole is provided under the floor mat at the front. Filters for circulating the inside air and outside air intake are detachable without any tool. Cleaning them has become easier.
- (6) A slant track frame and a mud trap the size of which has been enlarged 1.8 times as large as the previous one have been adopted for the new machine. Thanks to them, cleaning work including mud removing became easier than before. (See Fig. 22)

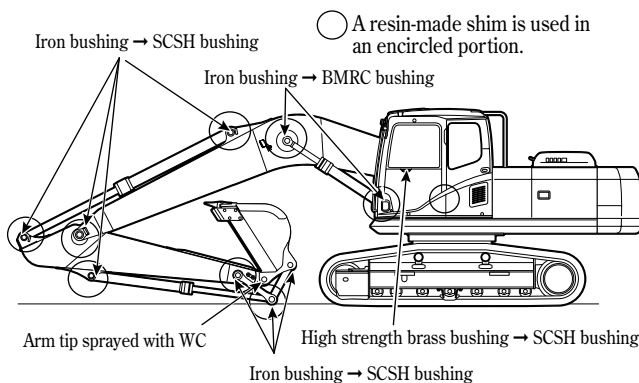
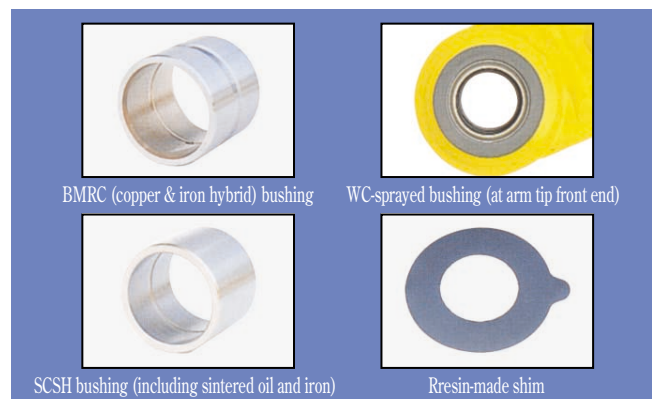


Fig. 21 Extended Greasing Interval for Work Equipment



Facilitating radiator cleaning

The radiator and the oil cooler are more distanced, facilitating cleaning with an air nozzle. Moreover, their single disassembly and installment are made possible now.



Rust-inhibited larger fuel tank

Fuel drain valve now remote-controlled



Water separator as standard specification

A newly installed water separator removes water contained in the fuel, warding off a trouble in the fuel system. It also serves a fuel pre-filter, greatly facilitating the maintenance work.



Eco-drain valve as standard specification

For the engine oil drain valve, an eco-drain valve is adopted. A hose connected to the valve tip helps prevent smudge on the clothing and the ground due to oil leak at the time of oil replacement.

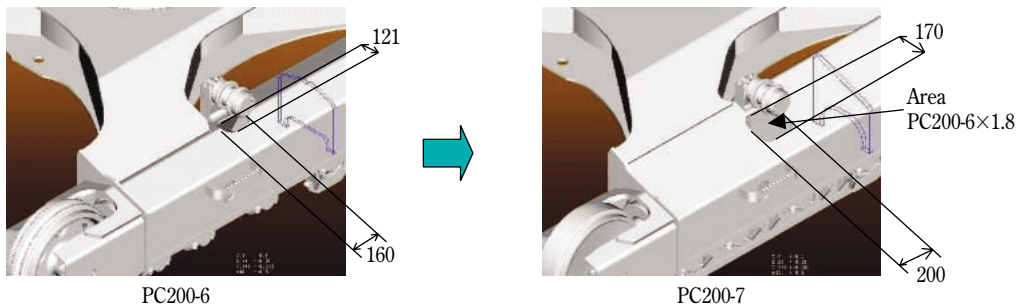


Fig. 22 Improved Maintainability

4. Conclusion

A new look PC200-7 in GALEO Series made debut on the occasion of Komatsu's 80th Anniversary that took place in May 2001 and went on sale in July of the same year. Its production in the overseas plants was commenced in December 2001. Currently they are produced in five plants in Japan, Southeast Asia, North America and Europe and are well accepted by customers all over the world.

Introduction of the writer



Yuuichi Iwamoto

Entered Komatsu in 1984. Currently working in Construction Equipment Technical Center 1, Development Division

[A few words from the writer]

The precursor machine, PC200-6, used to receive a wide attention on the global scene. A full model change of such a reputed machine brought about many conflicting interests among the parties concerned, and it was no easy job to reconcile them to everyone's satisfaction. But while groping for the optimum answer, we were lucky to have been supported by various people inside and outside of the company. Thanks to them, the model change has been brought to a successful end.