

## Introducing the LEO NXT Series 1- to 3-Ton Engine-Powered Forklift Trucks

Yasuo Seki  
Shin-ichi Katou  
Yoshiyuki Yoshida  
Tetsuya Okuyama  
Satoshi Takahara

*Komatsu Forklift Co., Ltd. has remodeled its best-selling, 1- to 3-ton engine-powered forklift trucks for the first time in seven years and has come up with the LEO NXT Series.*

*The LEO NXT Series has been developed with “No. 1” as the watchword. At the same time, newly-developed, compact 2-ton forklift trucks have been added to the product line.*

*We shall describe below the salient features of the LEO NXT Series.*

**Key Word:** *Engine Powered Forklift Truck, LEO NXT Series, 109 Series, Soft & Stable Cushion Tire, Super Lift Hydraulic System, Komatsu Advanced Power Steering, Visibility, Texture Paint, Recycle*

### 1. Introduction

Because of the growing concern about environmental problems, more and more engine-powered forklift trucks are being replaced by battery-powered forklift trucks. However, the engine-powered forklift truck is superior to the battery-powered forklift truck in terms of output and ease of fuel supply (improved infrastructure and good fuel efficiency). It may be said, therefore, that more and more users have come to choose either type according to the content of work to be done.

Under this condition, there is strong demand for engine-powered forklift trucks which are safe and friendly to the environment.

In addition, the current trend towards cutting the cost of distribution gives rise to the demand for a forklift truck which is as powerful as the engine-powered type and which is as compact as the battery-powered type. In view of such a market situation, Komatsu Forklift Co., Ltd. has remodeled its 1- to 3-ton engine-powered forklift trucks for the first time in seven years and has come up with the LEO NXT Series. At the same time, the company has added compact new 2-ton forklift trucks – the 109 Series – to the existing product line. The salient features of the LEO NXT and 109 Series are described below (**Photo 1** and **Photo 2**).

### 2. Aims of development

- (1) The primary aim of development of the new series was to come up with new engine-powered forklift trucks which are No.1 in every respect by making the most effective use of the company's core competence and to supply them to the customers. As the concept of No.1, the company placed emphasis on “stamina (reliability and durability), easing of stress (visibility, comfortable cab, and maneuverability), and design (clarification of Komatsu identity).” Another aim of development was to better meet the needs of individual customers with new products which are safe, economical, and friendly to the environment.
- (2) The company also aimed to develop compact new, 2-ton forklift trucks which are No.1 in compactness of body and material-handling performance. To that end, the company developed a new tire exclusive for compact-sized forklift trucks.



Photo 1 109 Series



Photo 2 2-ton Forklift Trucks

### 3. Models

In the present development, compact new, 2-ton models were added to the existing product line. At the same time, the minor models, intermediate models, and engine-powered models exclusive for exports were abolished or consolidated. On the whole, the 43 existing models have been reduced to 39 LEO NXT models with the aim of improving productivity (Table 1).

Table 1 Model series and engines mounted

LEO NXT model series		AX Series (1-ton models)					BX Series (2-ton models)							
		Wheelbase	0.9	1.0	1.35	1.5	1.75	Wheelbase	2.0	2.25	2.5	2.75	3.0	
Special small-sized vehicle	Gasoline engine	1400mm	○	○	○	○	○	1650mm	○		○			
	Diesel engine		×	□	□	□	□		×		×			
Standard vehicle	Gasoline engine			○	○	○	○			●	×	●	×	●
	Diesel engine			▲	▲	▲	▲			■	×	■	×	■
	Diesel engine			Engines mounted on vehicles exclusive for exports						×		×	×	
High-power vehicle	Gasoline engine						●		●	⊙		⊙		⊙
	Diesel engine							■		■		■		
Compact vehicle	Gasoline engine	_____	_____					1400mm	●		●		●	
	Diesel engine								■		■		■	

☐ : Maximum load

Legend

- (1) × : Models abolished
- (2) Specifications of engines

Newly established models

Gasoline	Model	Displacement (cc)	Output kW(PS)	Diesel	Model	Displacement (cc)	Output kW(PS)
○	H15	1486	27 {37}	□	4LB1	1499	23.5 {32}
●	H20	1982	34.5 {47}	▲	4D92E	2695	34.5 {47}
⊙	H25	2472	42.7 {58}	■	4D94E	2775	46.3 {63}
				■	4D98E	3318	53 {72}

#### 4. Exterior design

In designing the LEO NXT Series, we considered “the way the design of forklift trucks used in the field of physical distribution should be.” The main points are as follows.

- (1) Reliable and easy-to-use functions
- (2) Psychological appeal (making prospective customers feel like riding on, operating, or touching the machine)
- (3) Appeal to the sense of humans
- (4) Enhancement of the image of Komatsu brand
- (5) Demonstration of the originalities of Komatsu.

Concrete examples are given below.

- ① Attack line: The upper frame has been so shaped as to give the image of a line having an eye on game-agility, low center of gravity, strength.
- ② Spoon-curved fender: The fenders have been given a spoon-like curve so as to make the steps look wide and low.

All the other exterior parts have also been shaped elaborately and functionally (Photo 3).

Incidentally, LEO NXT standard 2-ton model (BX) series and 109 Series (compact models) won a **Good Design Award** for FY 2002. In 2003, the 109 Series also won the **Minister of Economy, Trade and Industry Award** – the highest of the 33rd **Mechanical Industry Design Awards** (sponsored by The Nikkan Kogyo Shimbun).

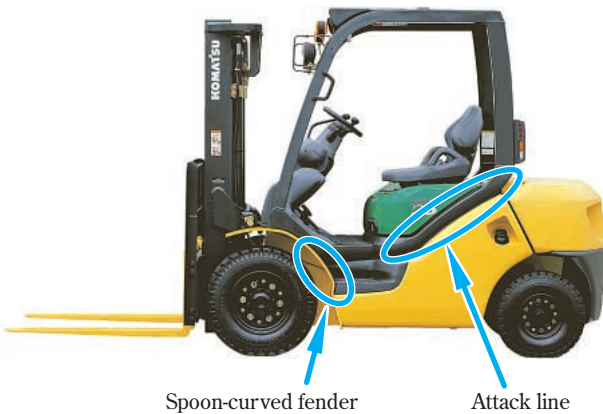


Photo 3 Exterior design

#### 5. Development of 109 Series of compact 2-ton forklift trucks

##### 5.1 Aims of development

There are user demands for: ① forklift trucks of larger capacity to handle larger and heavier materials and ② efficient utilization of interior space of warehouses, etc. In order to meet the demands for forklift trucks which have larger capacity than other models of the same class or forklift trucks which are more compact than other models having the same capacity, the company has come up with the 109 Series of compact 2-ton forklift trucks whose size is as compact as 1-ton models and whose material-handling capacity is as large as that of 2-ton models. The principal specifications of the 109 Series of forklift trucks are shown in Table 2.

109 Series: This series was so named because the machine width is 1,090 mm, which is smaller than the standard pallet size (1,100 mm × 1,100 mm) specified by T11.

Table 2 Comparison of principal specifications of vehicle bodies

	Overall length (mm)	Overall width (mm)	Overall height (mm)	Wheelbase (mm)	Minimum turning radius (mm)	Maximum load (kg) (5 m double mast)
Standard 1-ton vehicle (FD15)	3155	1070	2035	1400	1955	1150
Compact 2-ton vehicle (FD25N)	3450	1090	2025	1400	2050	1900
Standard 2-ton vehicle (FD25)	3645	1150	2070	1650	2240	1700

##### 5.2 Development of New Tire Exclusive for Compact Forklift Trucks

In order to reduce the size of forklift trucks as much as possible, the individual makers strain their faculties. The tires of forklift trucks are one typical example. To make vehicle bodies smaller, using smaller tires has long been called for. Cushion vehicles of U.S. specifications are provided with solid tires.

As the drawbacks of solid tires, poor riding comfort and inferior wear resistance can be cited. The new tire (soft & stable cushion tire: SSCT) the company has recently developed for compact models has an air vent in the sidewall. This air vent has improved the cushion performance and hence the riding comfort. The appearance of an SSCT tire is shown in Photo 4. As compared with the conventional solid tire, the SSCT has reduced the vertical acceleration of the operator's

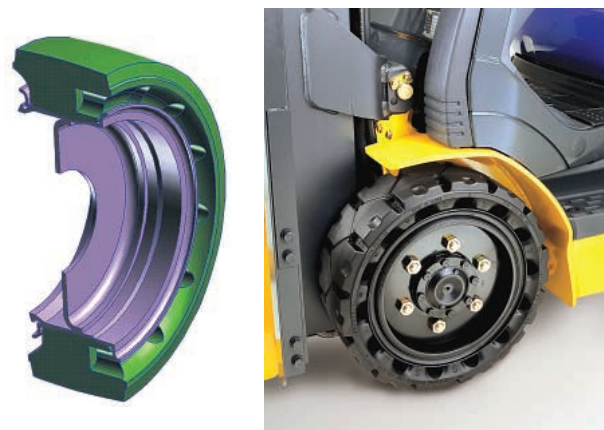


Photo 4 SSCT

sheet by 25% (based on comparison of the company's models). It is comparable in performance to the ordinary pneumatic tire.

Generally speaking, as the cushion performance is increased, the vibration damping characteristic deteriorates and the controllability of vehicle body pitching declines. In the case of the new tire, the vibration damping characteristic is as good as that of the conventional solid tire (Fig. 1).

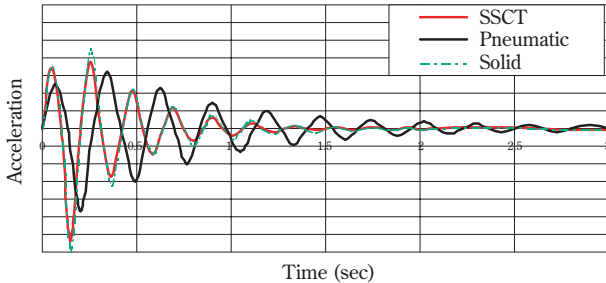


Fig. 1 Comparison of vibration damping characteristics

Since the air vent allows for uniform vulcanization of the rubber in the tire manufacturing process, the SSCT has wear resistance two times or so that of the conventional pneumatic tire.

Fig. 2 compares the characteristics of SSCT with those of other types of tires. Fig. 3 compares the shape of the new tire with that of the conventional tire.

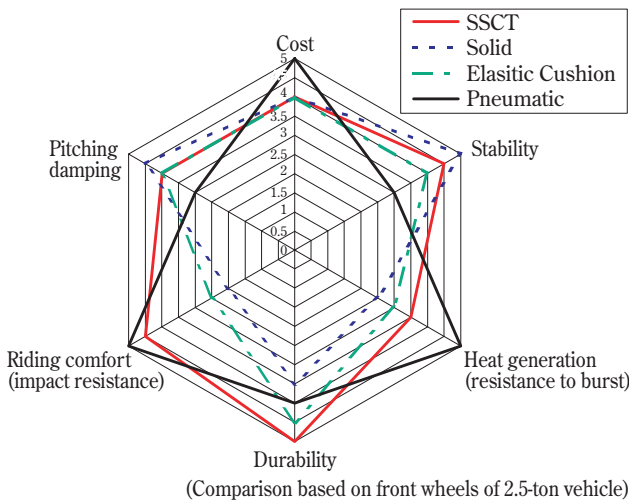


Fig. 2 Comparison of SSCT characteristics

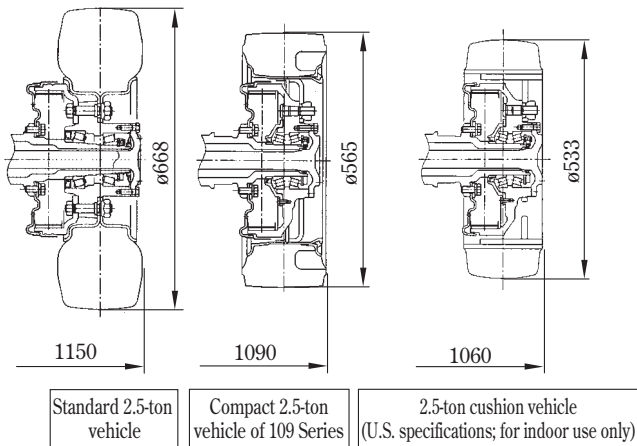


Fig. 3 Comparison of tire profiles (front tires)

## 6. Major features

### 6.1 Steering system

In addition to KAPS (Komatsu Advanced Power Steering) that combines Komatsu's original closed-type steering control unit and double rod steering cylinder, LEO NXT incorporates a new steering system named KAPS II to further improve the steering wheel maneuverability and vehicle running stability. The salient features of KAPS II are: ① A friction is applied to the center shaft of the steering control unit (Fig. 4) to prevent the control unit from being influenced by the deflection, etc. of the machine-body side steering link and thereby improve the steering response and straight running stability (patent pending), ② The centering spring force has been reduced so that even a small-diameter steering wheel can be manipulated with comparatively lightly, and ③ The valve opening has been optimized to reduce the circuit pressure drop. The new steering system is shown in Fig. 5.

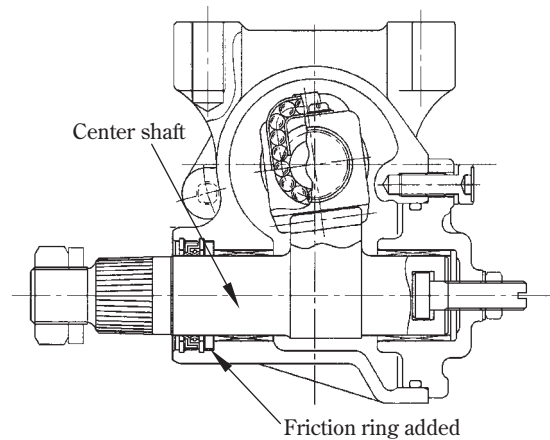


Fig. 4 Cross section of steering control unit

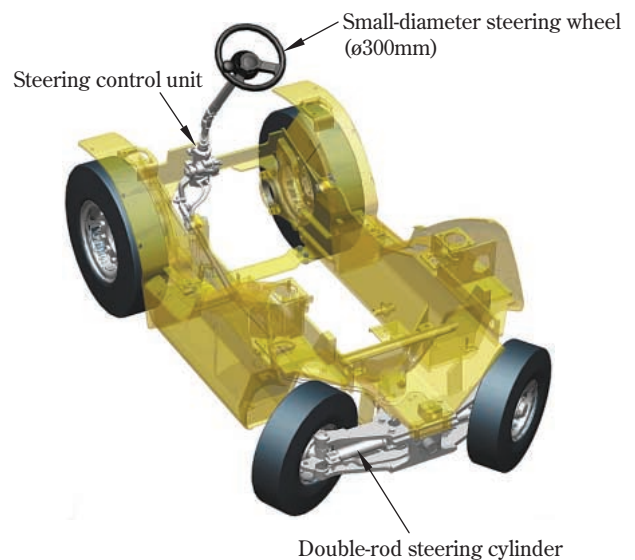


Fig. 5 Steering system



**6.2 Super lift hydraulic system (SLHS)**

In order for the operator to be able to control his machine completely, it is important that the work equipment should be capable of performing minute operations. For LEO NXT, the company has developed a compact tandem pump which makes the steering and work equipment circuits independent of the conventional pump (Fig. 6) (patent pending) so as to increase the work equipment speed while the engine is idling and permit the operator to perform material-handling work simply by manipulating the work equipment levers (Fig. 7). (With the conventional system, material-handling operation requires controlling the accelerator pedal as well.) In addition, since the work equipment speed does not affect the steering

operation, it has become easier for the operator to control his machine. As the new hydraulic system was adopted, the flow divider that was installed in the main pump circuit has been moved into the steering pump which is smaller in capacity than the main pump so as to improve the heat balance by reducing the circuit pressure loss and to increase the reliability of the hydraulic system. In order to prevent the engine from stalling when the work equipment and steering wheel are released at the same time, a bleeder valve is built in the flow divider so that the work equipment pressure is lowered automatically when the engine speed drops. Fig. 8 compares the new pump circuit with the conventional pump circuit.

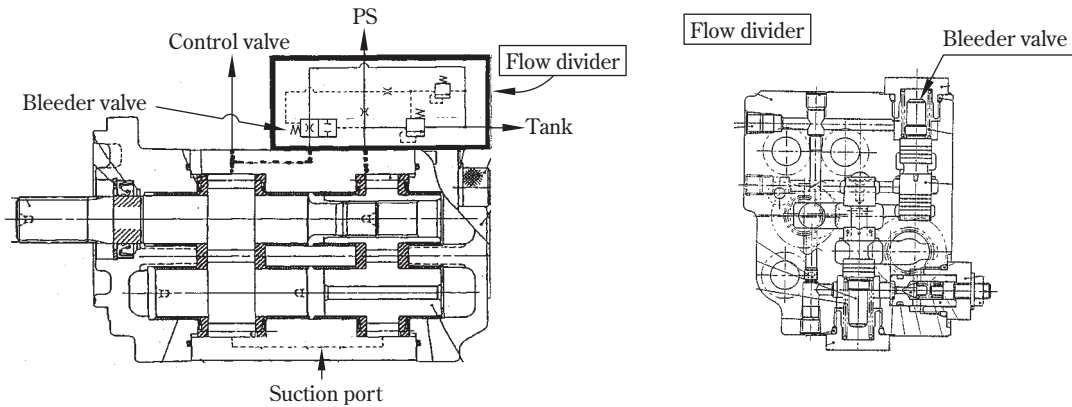


Fig. 6 Cross section of pump and flow divider

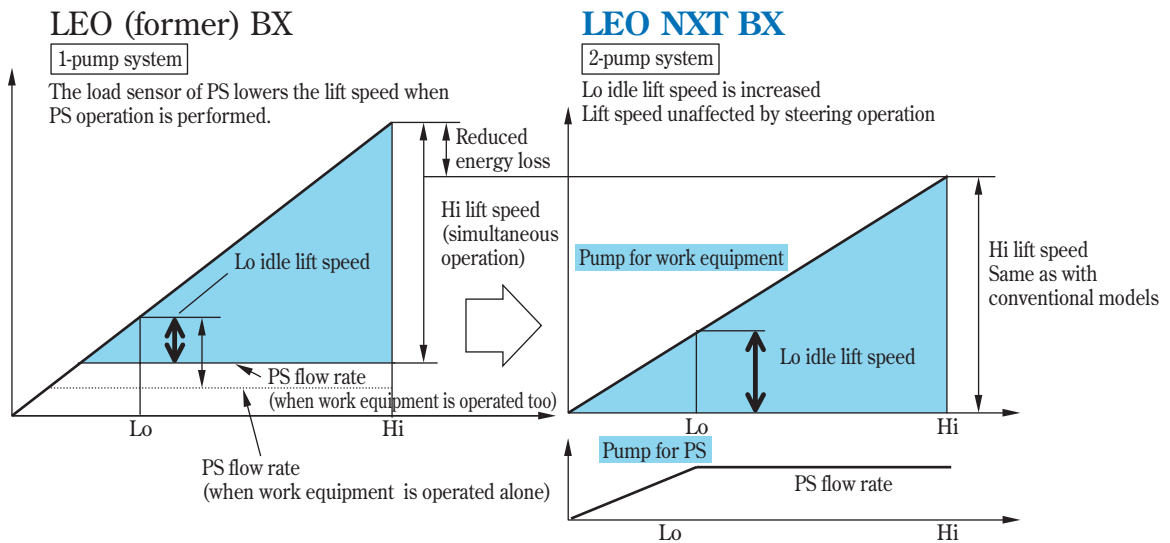


Fig. 7 Comparison of performance of hydraulic system

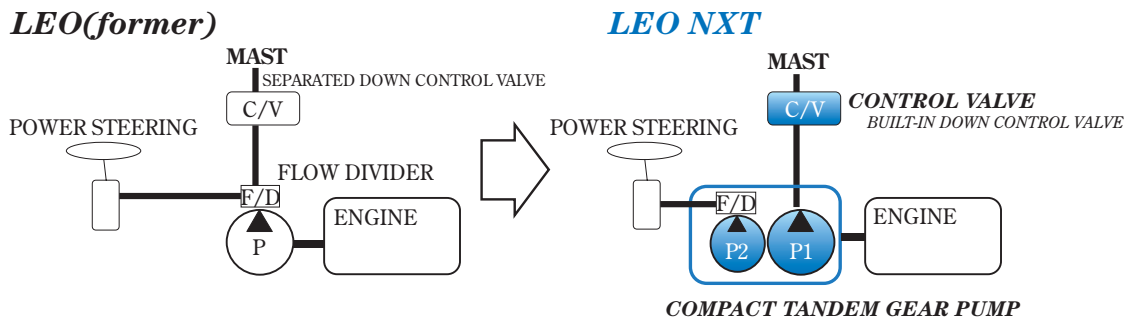


Fig. 8 Comparison of pump circuits

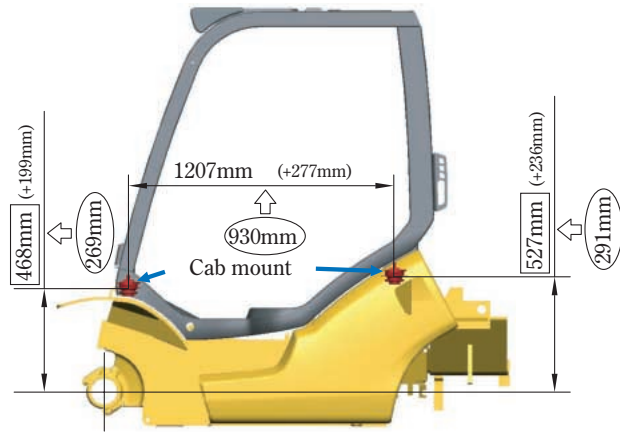
**6.3 Riding comfort and cab space**

From the viewpoint of easing the operator's stress-one of the concepts of the present development, affording good riding comfort and comfortable cab space to the operator is an important requirement. LEO NXT has improvements on the following points.

(1) Riding comfort

① Cab mount position and characteristics

The cab mount position has been raised to move it closer to the operator sitting position. At the same time, the longitudinal span has been widened to reduce the vibration the operator feels. This has made it possible to decrease the spring constant (Fig. 9).



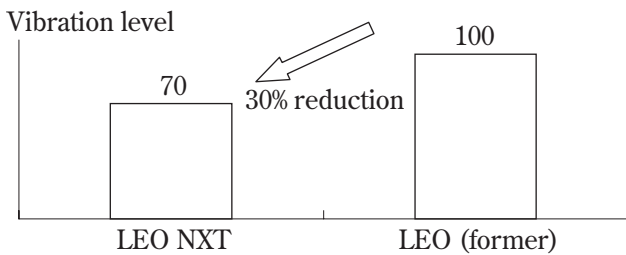
□ Dimensions: LEO NXT, ○ Dimensions: LEO (former)

**Fig. 9** Cab mount position

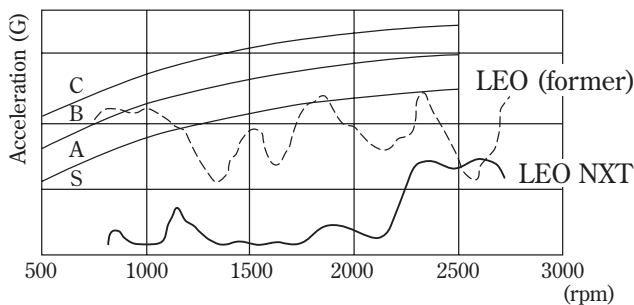
② Operator's seat

The layout of the suspension links, springs, and dampers was reviewed. The thickness of urethane padding of the operator's seat was increased by 70% and the link efficiency was improved, thereby making the seat feel softer and reducing the unstable feeling of a comparatively long stroke.

The levels of seat vibrations when the vehicle is running on irregular ground and on level ground are shown in Fig. 10 and Fig. 11.



**Fig. 10** Comparison of vibration level when vehicle travels irregular ground



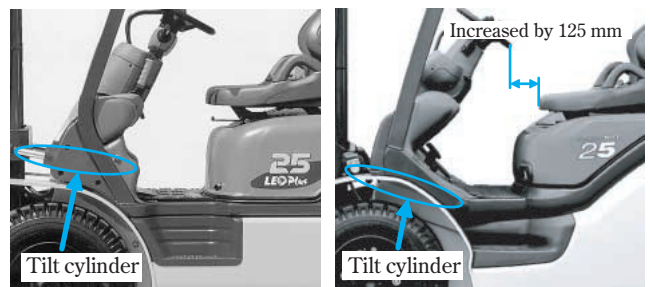
**Fig. 11** Seat position vibration

(2) Cab space

Tilt cylinders have been arranged under the floor to eliminate the projected parts on both sides of the floor, thereby securing a wide floor space. The operator's left foot is set free while the vehicle is running. Therefore, the footrest provided on the left side is effective to reduce the operator's fatigue. In addition, the small-diameter steering wheel and operator's seat have been set back and the clearance between the steering wheel and seat has been increased by 125 mm (as compared with conventional models) to provide a wider working space (Photos 5 and 6). The stroke of the sliding seat is 160 mm (80 mm to the front and 80 mm to the rear, from the normal position). For the benefit of an operator of small stature, a space for moving the seat forward is provided inside the bonnet.



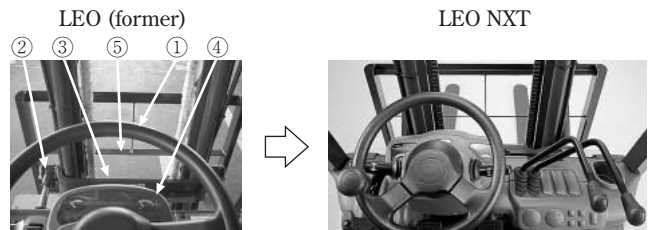
LEO (former) LEO NXT  
**Photo 5** Comparison of work environment (1)



LEO (former) LEO NXT  
**Photo 6** Comparison of work environment (2)

**6.4 Front Visibility**

With 3D-CAD which was utilized in the present development, careful attention was paid to the front visibility, especially the visibility of the fork, from the planning stage. As a result, the new models offer much better front visibility than conventional models. Photo 7 compares the front visibility between the new and conventional models. The contents of the improvements are also shown.



- ① Outer diameter of steering wheel is decreased. (ø360 → ø300)
- ② Position of tilt cylinder is lowered.
- ③ Position of tilt stay is lowered.
- ④ Compact meter panel is utilized.
- ⑤ Inclined backrest lower plate is utilized.

**Photo 7** Improved front visibility

**6.5 Environmental Consideration**

(1) Texture paint

Formerly, in order to obtain uniform casting surface of the counterweight and improve its appearance, application and grinding of putty was implemented before painting of the counterweight. Grinding putty is hard work in an unfavorable environment as it produces dust. Besides, when the counterweight is scratched, the putty of that section comes off, causing a nuisance to the user. On the part of the dealer, the exposed part needs to be repaired when the machine is resold.

In order to solve all those problems, the paint film surface was artificially made to look like pear skin so that the paint on the casting surface looks natural. As a result, it became possible to eliminate the process of applying and grinding putty (Fig. 12, Photo 8).

(2) Counterweight dividing groove

The counterweight was provided with grooves in the inner surface for making it easier to divide the counterweight by a press. This has improved the recyclability of obsolescent counterweights (Fig. 13, Photo 9).

**6.6 Serviceability**

In addition to the conventional bonnet structure that can be opened, LEO NXT employs a floor-plate structure that can also be opened (Photo 10). With conventional models, it is necessary to take the trouble to remove the floor mat and floor plate when checking the torque converter oil, oil leak from around the control valves, etc. With the new models, there is no need to remove the floor mat and floor plate. In addition, the bonnet and floor plate are detachable (patent pending). The radiator reserve tank, fuses, and relay box are all arranged near the battery to facilitate inspection of them.

**6.7 Reliability**

(1) Heat balance

During the present development, the existing company standards were reviewed to improve the heat balance.

- ① Engine cooling water temperature: The standard shall be met with the radiator clogged 10%.
  - The shape of the plastic shroud has been optimized.
- ② Torque converter oil temperature: The standard shall be met in V-shape mode (i.e., the mode in which plugging operation is performed frequently).
  - The torque converter cooler capacity has been increased (2.8 times that of conventional models)
- ③ Hydraulic oil temperature: The standard (10°C lower than the former standard) shall be met.
  - Pressure loss of the hydraulic circuit has been reduced.
  - A hydraulic oil cooler built in the radiator has been added.

(2) Wiring

Clips have been added to the harness side and all Ty-raps have been abolished to prevent the loosening/scratch of wires due to improper assembly. In addition, actual models were subjected to water spray test to check for abnormal conditions.

(3) Piping

In addition to improving the heat balance, the connectors of the steering circuit – a critical part – have been provided with flat face-to-face O-ring seal to prevent oil leakage.

- The reliability of wiring and piping has been improved

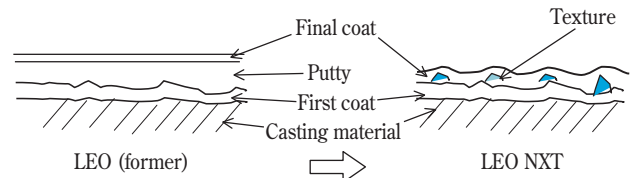


Fig. 12 Cross section of painting



Photo 8 Appearance of texture paint

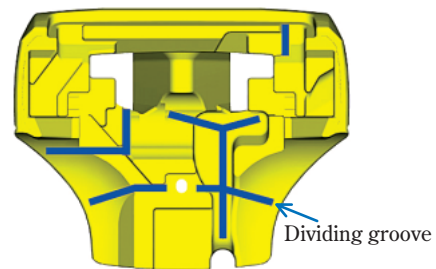


Fig. 13 Counterweight dividing groove



Photo 9 Divided counterweight

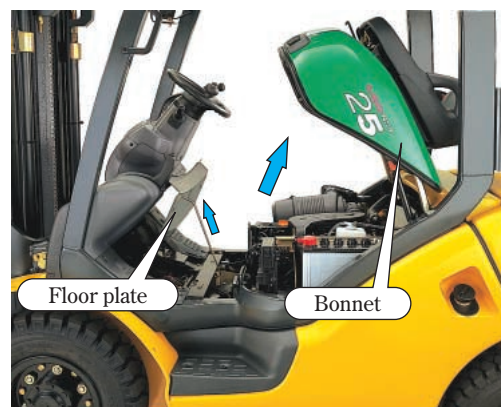


Photo 10 Floor-plate structure that can be opened



through the optimization of wiring/piping length and clearance by utilizing Pro Cabling and Pro Wiring based on 3D-CAD and through the checking of actual vehicles by the check sheet specified by F KES.

(4) Prolongation of guarantee period

In addition to the improvements described above, the bench test which was formerly applied chiefly to the power line and mast is applied also to the machine-body components to improve the overall reliability of vehicles. As a result, the guarantee period has been extended from “6 months or 600 hours of operation, whichever is shorter” to “12 months or 1,200 hours of operation, whichever is shorter.”

## 7. Conclusion

Since introduction in July 2002, LEO NXT has been favorably received by the market. All the aims of the development of LEO NXT are also evaluated favorably by the customers. In particular, the newly-developed 109 Series is highly rated for its exceptionally compact size.

The most formidable rival to compact engine-powered forklift trucks is the battery-powered forklift truck. So, the major task to tackle in the future is to reduce the levels of vibration, noise, emissions, etc. close to those of battery-powered forklift trucks while maintaining the advantages of engine-powered vehicles.

## Introduction of the writers



### Yasuo Seki

Entered Komatsu Forklift Co., Ltd. in 1975. Currently working in Development Group, Development Division, Komatsu Forklift Co., Ltd.



### Shin-ichi Katou

Entered Komatsu Forklift Co., Ltd. in 1981. Currently working in Simultaneous Planning Group, Development Division, Komatsu Forklift Co., Ltd.



### Yoshiyuki Yoshida

Entered Komatsu in 1981. Currently working in Hydraulics R&D Center, Engine & Hydraulics Business Division, Komatsu.



### Tetsuya Okuyama

Entered Komatsu in 1991. Currently working in Development Group, Development Division, Komatsu Forklift Co., Ltd.



### Satoshi Takahara

Entered Komatsu Forklift Co., Ltd. in 1991. Currently working in Development Group, Development Division, Komatsu Forklift Co., Ltd.

## [A few words from the writers]

A field supervisor of one of our customers told us that the new forklift truck has such a good running stability that it moves straight ahead even when your hands are kept off the steering wheel. We sure know that our new forklift trucks have excellent running stability. However, driving the vehicle with hands off the steering wheel is not commendable. A warning against it is included in the texts of the product catalogs and user's manuals. We thought that it would be nice to have the customer's voice heard directly by the people who planned the new series and the designers who have made painstaking efforts to mass-produce the wonderful new vehicles.