Model change of the "NICHIYU PLATTER" Electric Forklift Stand-on Reach Truck

Mitsubishi Nichiyu Forklift Co., Ltd.

The Nichiyu-branded reach forklift truck, the Platter (load capacity of 0.9 to 4.0 tons), underwent a complete model change for the first time in 12 years, and sales of the new model commenced in January 2015. The new Platter was developed based on the main concept of "a product excellent in terms of ecology and economy," and its energy saving performance, safety performance, and basic performance of moving, turning, braking, and lifting were reviewed. Furthermore, a function to establish the operating feel that the operator desires has been added in response to the growing diversity of operators. The development was conducted targeting a product that all users – from beginners to experts – can use comfortably for many years. This paper presents the features of the new Platter FBR-80.

1. Introduction

The electric reach forklift truck was a cargo handling vehicle that was developed collaboratively by Nippon Yusoki Co., Ltd.(note) and Nippon Express Co., Ltd. in 1958 for the first time in Japan for the purpose of handling cargo on the platforms of railway stations and in freight train cars (**Figure 1**).

Figure 1 The first electric reach forklift truck

(note) Nippon Yusoki Co., Ltd. and the forklift truck section of Mitsubishi Heavy Industries, Ltd. have merged to establish Mitsubishi Nichiyu Forklift Co., Ltd. on April 1, 2013.

The cargo handling vehicle was named Platter referring to the word "platform."

An electric reach forklift truck is equipped with a reach mechanism where the entire mast that raises and lowers the cargo can be slid back and forth. Due to the biggest benefit, its small turning circle, electric reach forklift trucks are actively used in warehouses with narrow aisles in various fields ranging from food to heavy industry. The standing riding-type operating posture, which allows the operator to get on and off easily, is suitable for work that requires the operator to perform other tasks in addition to the operation of the forklift truck, such as picking work in a warehouse.

2. Enhancement of energy saving performance

Using the newly provided Eco-mode, which suppresses the maximum performance of the moving speed and the lifting speed, the electric power consumption can be reduced. In addition, by reviewing higher piping resistance components including the replacement of elbow hydraulic fittings with bend fittings, the energy loss of the hydraulic system, for which the electric power consumption was particularly large, was reduced. The new model reduces electric power consumption by 15% (obtained by in-house measurement) in comparison with the old model.

3. Enhancement of safety performance

(1) In addition to the moving and cargo-handling interlocking system that has been equipped on existing models in order to disable moving and cargo-handling operation according to the ISO 3691 safety standard when the operator is not riding the forklift truck properly or is absent from the cockpit, a pedal-type presence switch that is located so as to prevent the forklift truck from moving when the operator's right foot is outside of the cockpit was newly provided. This results in safer posture of the operator while moving (**Figure 2**).
ISO 3691 describes that a forklift truck with a step higher than 300 mm needs to be equipped with a handle. The new 2-ton load capacity class forklift truck model has such a step, and therefore a handle for getting on and off was installed. The handle was also installed on the new 1-ton load capacity class forklift truck model with a 265-mm-high step, which contributes to safety and the reduction of fatigue when getting on and off (**Figure 3**).

Figure 2 Pedal-type presence switch

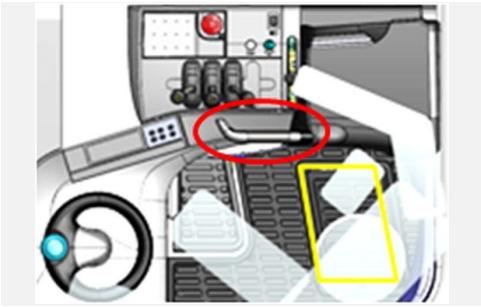

Figure 3 Handle for getting on and off

(2) The operation levers were moved toward the center of the forklift truck by approximately 30 mm in comparison with the old model. This layout allows the operator to stand facing obliquely leftward as the basic posture, which rarely leads to an accident caused by the operator putting out his or her right elbow during operation (**Figure 4**).

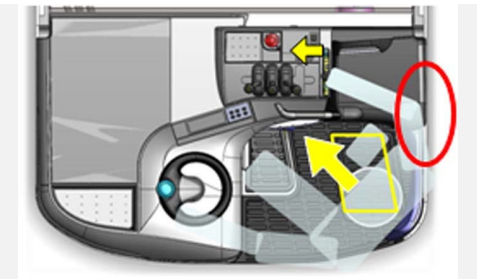

Figure 4 Operation lever layout that rarely leads to an accident

(3) The charging plug was provided with a handle. This allows easy plugging in and removing the plug, and rarely results in improper plugging or plug breakage.

(4) An optional charging monitoring system that monitors any abnormalities while charging and issues a warning in the case of the risk of a fire is available. This system stops charging operation and sounds a horn to inform people in the surroundings if an abnormal electric current in the transformer or an abnormal temperature at the vehicle-side charging plug is detected.

(5) Anti-slip control was provided as standard and attained more stable operation on slippery floors. Attitude change while plugging (moving forward and backward by operating the

accelerator) and braking was minimized and the breaking distance was shortened. By detecting the rotation speeds of the right front wheel and the driving wheel as well as the steering angle, slippage of the driving wheel is calculated and the power output of the driving wheel is controlled appropriately to suppress slippage.

(6) According to the electricity-related requirements of ISO 20898, the plugs were color coded in red for 24 V and blue for 48 V in order to prevent misconnection between different voltages of batteries. In addition, the plugs were replaced with those for which misconnection is physically impossible.
In addition, the old model has an emergency stop switch that mechanically disconnects the battery plug when activated. However, the new model adopts a breaker-type emergency switch that electrically shuts off the power when activated.

4. Improvement of basic performance

(1) The control linkage was improved in order to enhance the moving stability (**Figure 5**).
It is characteristically difficult for this vehicle to attain a well-balanced moving attitude because driving, braking, and steering of the vehicle rely on the single drive wheel positioned at the left rear of the vehicle. The driving wheel and the caster wheel are linked by the control linkage through a spring and these components constitute the rear axle. This structure allows the wheel pressure of the driving wheel to be kept constant regardless of the roughness of the floor, or increase and decrease the rear wheel axle load during reach operation. This makes it possible to generate stable driving force even when the vehicle is loaded with cargo and stabilizes the attitude of the vehicle. On the other hand, if the vehicle is turned suddenly (toward the left in particular) under an unloaded condition, the center of gravity moves toward the caster wheel side and the left front wheel located on the opposite corner lifts easily. To prevent this, the vehicle is equipped with a locking cylinder in order to restrict the operation of the control linkage when the vehicle is turning. In the case of the old model, lowering of the body toward the caster side occurred as an effect of the caster side spring because the locking cylinder was installed on the driving side, and this was an issue that needed to be solved.

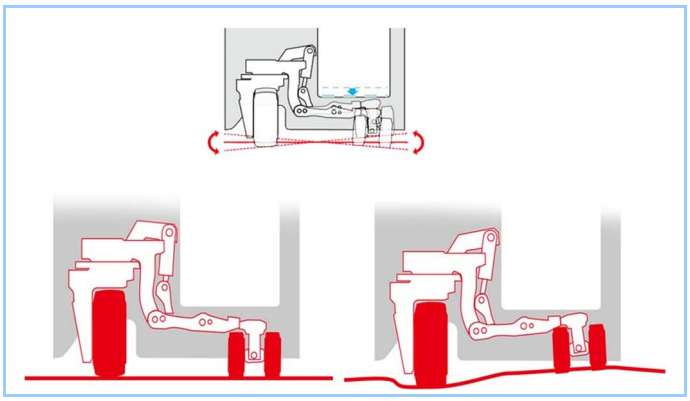

Figure 5 Control linkage

Figure 6 Locking cylinder that restricts linking action of caster wheel (Circled in red)

For the new model, the structure was changed so as to apply locking to the caster wheel side linkage, which was conventionally difficult because of insufficient installation space, etc., and the sinking of the caster wheel was reduced. (**Figure 6**)
In addition, by finely controlling the locking cylinder activation timing in response to the conditions of the moving speed and the turning angle, the turning stability was significantly enhanced. By activating the lock, the stability was enhanced not only in terms of turning, but also in terms of cargo handling. The swinging amount was increased in order to enhance the moving performance against the roughness of the floor.
While the cockpit floor height was lowered by 50 mm in comparison with the old model for easier getting on and off and for the reduction of the fatigue of the operator, the swinging amount of the control linkage was increased as described above. This lowered floor was attained using an under-floor caster wheel of the same outer diameter as that of the old model

without reducing the wheel diameter, and therefore the wheel wear life is not shortened and the riding comfort is not degraded.

(2) A custom feeling system that can realize an operating feel according to the tastes of various operators was provided as standard. (**Figure 7**)
This system allows the characteristics of the acceleration, response, and lever operation to be adjusted according to the taste of the operator.
In distribution warehouses where the cargo varies from hour to hour, there are various operation patterns such as those focusing on speed and the others requiring careful cargo handling.
The custom feeling system is intended to meet not only the taste of the operator, but also the safety management policy of each distribution site in order to support safer and more secure cargo handling. Three custom feeling settings can be set for each aspect.
This is the first time that a function such as this has been provided for a forklift truck.

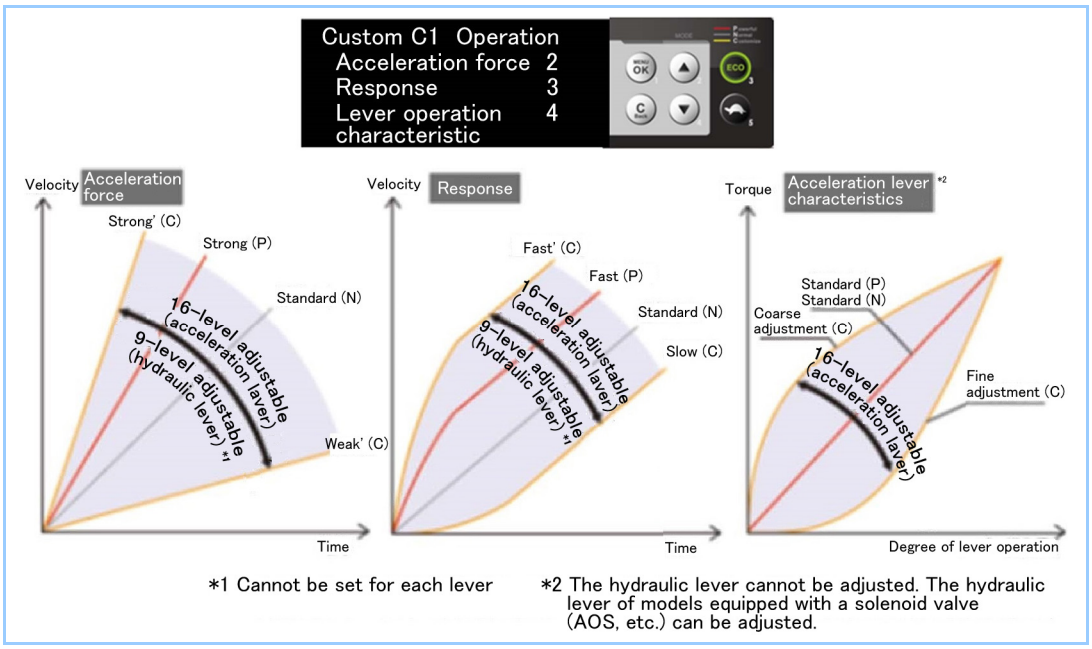

Figure 7 Custom feeling

5. Design

(1) The new Platter was finished by pursuing excellent operability that can satisfy expert operators through visits to the actual work sites of customers, as well as by repeated research of use conditions. To attain this, the following were intensively examined.
- The properties of the handle: height, longitudinal position, and angle of rotating shaft
- The layout of the accelerator lever and the cargo handling levers, and the stroke of the accelerator lever
- The layout of the underfoot safety interlock (presence pedal)
- The body supporting function (the height of the arm pad, the shape of the waist pad, the shape of the new grip)
- The layout of the display, the angle of the screen, and the screen display viewing angle
- Sufficient area of the document table
- The new small storage container

After the dimensions and direction related to these design examinations were determined, the new Platter was designed by pursuing the establishment of a simple design with no discontinuity without increasing the shape lines unnecessarily and complicating the face constitution, targeting a design that facilitates lengthy use.

(2) The new Platter was highly evaluated also in terms of design, and received a "100 Best Good Design Award 2014" from the Japan Institute of Design Promotion (JDP) and a "46th Machine Industry Design Award 2016, Japanese Brand Prize" held by Nikkan Kogyo Shimbun. (**Figure 8**)

Figure 8 Highly-evaluated design

6. Specifications

Table 1 Specifications

Classification	Item	Remark	Unit	Narrow type	Standard type			
Type	Voltage			24V vehicle	48V vehicle	48V vehicle	48V vehicle	48V vehicle
	Vehicle type			FBR(M)10N	FBR(M)10	FBR(M)15	FBR(M)20	FBR(M)30
	Rated load		kg	1000	1000	1500	2000	3000
	Load center distance		mm	500	500	500	500	500
	Electric motor type	DC/AC, Open/Sealed		AC	AC	AC	AC	AC
Dimensions	Standard lift		mm	3000	3000	3000	3000	3000
	Free lift		mm	105	105	105	120	125
	Tilt of fork	Forward/Backward	deg	3/5	3/5	3/5	3/5	3/5
	Fork shape	Length/Width/ Thickness	mm	850/100/35	850/100/35	850/100/35	920/122/40	920/122/44
	Overall length	To tip of forks	mm	1885	1920	2010	2205	2310
	Reach		mm	475	420	590	675	835
	Overall width		mm	990	1090	1090	1190	1230
	Frame width		mm	990	1090	1090	1190	1190
	Overhead guard height		mm	2220	2220	2220	2280	2280
	Floor height		mm	265	265	265	315	315
	Turning radius		mm	1350	1340	1580	1785	2050
Performance	Travel speed	Laden/Unladen	km/h	9.5/10.5	10.5/10.5	9.5/10.5	10/11.5	9.0/11.0
	Lift speed	Laden/Unladen	mm/s	265/450	340/540	310/540	290/490	220/400
Weight	Weight	Including standard battery	kg	1780	1890	2100	2790	3210
Driving components	Number of wheels	Laden wheels/Driven wheels/Free wheels		2/1/2	2/1/2	2/1/2	2/1/2	2/1/2
	Wheel base		mm	1105	1085	1335	1515	1785
	Track width	Front	mm	875	975	975	1075	1095
		Rear	mm	565	640	640	695	695
	Main brake	Mechanical/Hydraulic /Electric/Air		Mechanical	Mechanical	Mechanical	Mechanical	Mechanical
	Parking brake	Stepping/Manual/ Deadman		Deadman	Deadman	Deadman	Deadman	Deadman
	Battery	Voltage/Nominal capacity (5h)	V/Ah	24/390	48/201	48/280	48/320	48/370
		(min/max) Weight (including case) (min/max)	kg	315 (300/450)	355 (340/450)	470 (450/750)	550 (525/900)	575 (560/900)
	Drive motor	Motor type		AC induction motor	AC induction motor	AC induction motor	AC induction motor	AC induction motor
		Output (60 min rating)	kW	2.6	4.3	4.3	5.0	5.0
	Lift motor	Motor type		AC induction motor	AC induction motor	AC induction motor	AC induction motor	AC induction motor
		Output (5 min rating)	kW	6.0	8.8	8.8	11.0	11.0
	Power steering motor	Motor type		DC magnet motor	DC magnet motor	DC magnet motor	DC magnet motor	DC magnet motor
		Output (60 min rating)	kW	0.15	0.3	0.3	0.3	0.3
	Battery charger	Type (Built-in/Separate)		Built-in	Built-in	Built-in	Built-in	Built-in
		Charging type		Semi-constant voltage a utomatic charge	Semi-constant voltage automatic charge	Semi-constant voltage automatic charge	Semi-constant voltage automatic charge	Semi-constant voltage automatic charge
		Input (number of phases/voltage)	/V	3/200	3/200	3/200	3/200	3/200
		Transformer capacity	kVA	3.0	3.0	3.6	5.2	5.2