Introduction of Product

Development of Small-sized Crawler Dozers "D31/37/39-21" with Electronically Controlled HST

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We surveyed distributors and job sites in North America, or the main market of small-sized crawler dozers, for the purpose of reflecting users' opinion on our development work. According to the result of our survey, we made a minor changed and upgraded models D31/37/39-21, which are described below, centering on their new features and other topics.

Key Words: *Electronically Controlled HST, Small Crawler Dozer, KOMSTAT 2, Two Selectable Modes for Travel Speed, Preset Function of Reverse Travel Speed, Motor Speed Sensor, Servo Pump, Counter-Rotation Turn, Electric Travel Control Joystick.*

1. Background of development

We started selling D39-21 in April 2001 and D31/37-21 in December 2001 installed with a servo-less hydraulically direct controlled HST (Hydrostatic transmission) unit. Meanwhile, competitive manufacturers took the offensive against Komatsu by introducing to market machines with electronically controlled HST having a servo system.

Conventionally, the performance required of small-sized crawler dozers was a recognizably smooth turning, shock-less gearshifting, and high-precision grading performance. However, upon investigating the market, it was found that the largest number of demands were being directed not only toward maneuverability with counter-rotation (to rotate both tracks in different direction each other) and fine speed control but also toward agility and powerfulness such as large drawbar pull for dozing while turning (speed), mobility when traveling and turning on upslope, etc.

This report describes respective features incorporated into the development machine based on the concept of "PIVOT ON THE CUSTOMER." (**Photo 1**)

Photo 1 General view of D39PX-21

2. Aims of development

This development aims at incorporating the customers' demand into the products to improve our market share. To this end, we visited 11 principal distributors in North America to directly discuss their requirements with management, sales, and service personnel. We searched for sales points and catch-up items to contribute to increasing the share and to promote product development project.

1) Points favorably evaluated on existing machines

We thought that the strong points of existing machines should be inherited as they are. Upon checking, they boiled down to the following three points:

- Excellent machine stability, smooth turning, and subsequent grading performance
- Palm Command Control System (PCCS) evaluated as non-fatiguing after continuous operation for extended hours
- Quiet cab with ample space for operation and superb forward visibility

2) Customers' requests and key points to be caught-up

What we should do to positively increase our share is to eliminate items that hinders sales and to incorporate features desired by customers into our products. (**Fig. 1**) The above can be summarized into the following three main points:

- Advanced technology provided by an electronically controlled HST with a servo system and powerfulness demonstrated at dozing while turning, etc.
- Operating system that allows simple selection of travel speed in every speed range with a switch and a monitor panel for showing details of operation with ease
- Improved blade and hitch workability and development of long-life joint for blade mounting

Basing our design concept on investigation results, we began development.

Incorporation into minor change machines
●:Incorporated,
—:Not incorporated

AA:Strong requirement ····· 2 points
A :Request & Requirement ····· 1 point
B :Slight Request ····· 0.5 points

	Request & Requirement	North American distributors											Total
		A	B	C	D	E	F	G	H	I	J	K	
●	1. Powerful steering with electronically controlled HST	AA	AA	AA	AA	AA			AA	AA	AA	AA	18
●	2. Infinite travel speed control with detent	A	A	AA	AA	AA			A	AA	A	B	12.5
—	3. 6 cylinder engine for reliability		B	B		B		A	B			A	4
—	4. Easy to clean radiator for forest application							A					1
—	5. Up-dated & hexagonal cab design			A									1
●	6. Blade design should be improved - Pushing material does not roll up well	A		AA	AA	AA					A	A	9
—	- Blade pitch adjustment	B		B		B					B	B	2.5
—	- Blade visibility for grading	B					A						1.5
●	- Center ball life should be extended	A							AA			B	3.5
●	7. Extended hitch by 6" to the rear	AA	AA	AA	A	AA	A		AA			A	13
●	8. 27" width shoe for D39PX as an option				AA				B				2.5

Fig. 1 Survey of North American distributors on their requirements and incorporation into the minor change machines

3. Means for achievement and sales points

1) Fully electronically controlled HST system

a) Powerful electronically controlled HST

Current machines have adopted the HST control system with servo-less hydraulically direct control mechanism. Features include a simple control system. This can automatically reduce pump capacity within the pump control system according to the increase of external load. This reduces engine hunting and the impact of the load change. Travel speed control, however, is determined by the balance between the pilot pressure of the travel PPC control and the HST circuit pressure. Consequently, there may be cases where the engine output cannot be fully utilized, particularly with the inner track at dozing while turning. (**Fig. 2**)

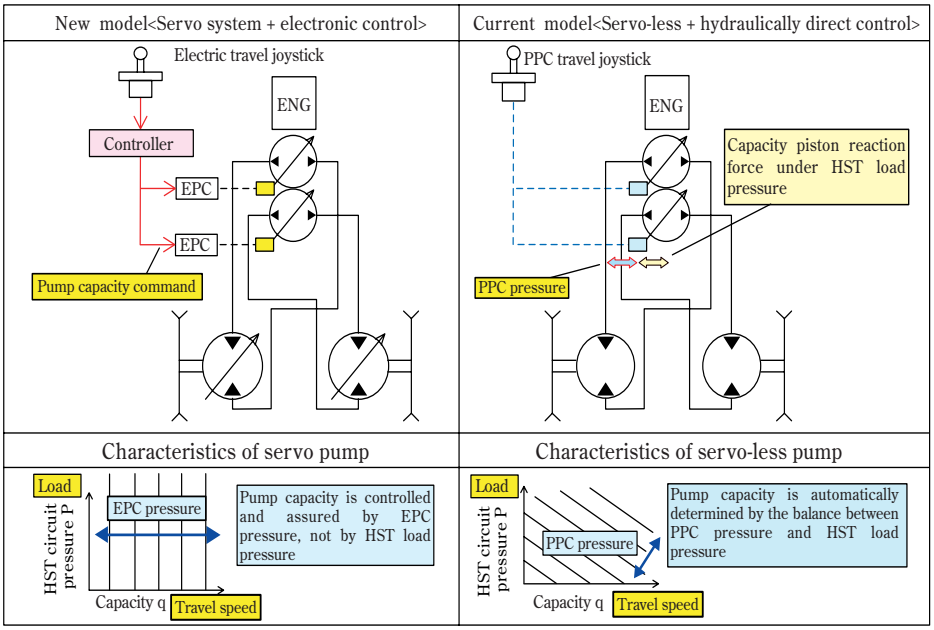


Fig. 2 Comparison of servo-less hydraulically direct controlled system and electronically controlled system with servo

To solve this problem, we added the servo system, and had the controller determine optimal pump capacity on the basis of engine speed (rpm), state of external load (HST circuit pressure), lever operation data, etc. As a result, we succeeded in delivering maximum engine power to the sprocket under every working condition. (**Fig. 3**)

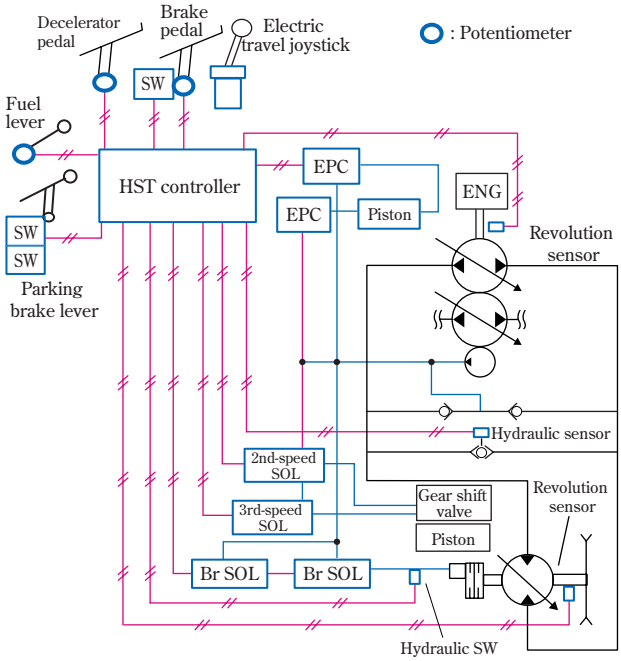


Fig. 3 Electronically controlled HST and brake system

Moreover, to retain smooth turning and gear shift operation that favorably evaluated on the existing machines, tuning was optimized according to machine condition. In addition, in order to achieve smooth turning operation, we adopted new logic to expand the fine control mode range.We could thus achieve compatibility between power and smoothness. (**Fig. 4**)

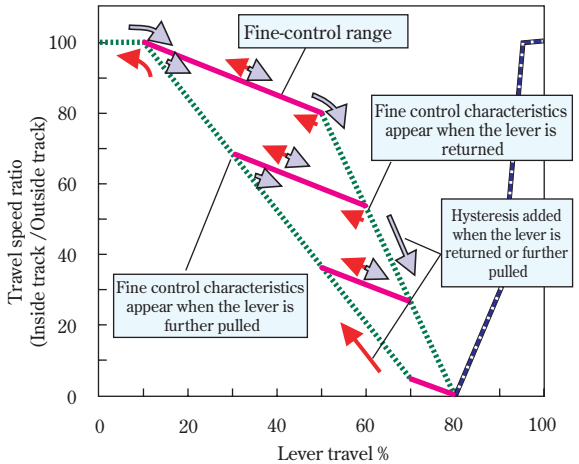


Fig. 4 Steering characteristics

In addition, we made it possible to sense revolution finely with a newly developed Hall IC revolution sensor. Since straight-ahead tracking performance is improved by continuously controlling the L.H. and R.H. pumps based on the detected difference between left and right travel speed, valve adjustment to synchronize speeds of both tracks is eliminated.

b) Safety Design of the Brake system

The brake pedal is equipped with a potentiometer and a limit switch to provide redundancy for safety reasons. Depressing the pedal half way gradually reduces the pump capacity to control travel speed (hydraulic braking). When the pedal is further depressed, the mechanical brake by the disc inside the motor applies. Also, the parking lever is provided with two limit switches and the electric circuit for mechanical brake actuating is equipped with two solenoids. For safety purpose redundancy, if one of them becomes faulty, an error code will show on the display panel and the remaining device normally functions to prevent hazards from occurring. (**Fig. 3**)

2) Travel and directional control joystick and electronic monitor panel

a) Palm Command Control System (PCCS) Joystick for travel speed setting

The travel speed setting, that was originally performed by positioning the joystick on the way of the lever travel for the forward or reverse, has been replaced by a new method in which the travel speed for all ranges can be set with ease by pressing the Up/Down button located at the thumb position on the joystick top after setting the joystick to forward/reverse position. (**Photo 2**)

b) Successive speed setting with shift mode switch (variable speed mode)

Pushing the travel joystick into the forward or reverse positions and depressing the Up/Down button results in changing the travel speed successively from 0.8 km/h to a maximum 8.5 km/h. Accordingly, travel speed can be finely selected depending on the working conditions or the operator's preferences. (**Fig. 5**)

c) Quick shift using the conventional shift method (quick shift mode)

The travel speed of conventional torque converter or hydroshift crawler dozers is F3-R3. These machines are still widely used in the market. To satisfy operators who are unhappy with the change in operating systems, speed shift mode can be easily converted to the F3-R3 shift mode by turning the shift mode switch located at the right-middle side of the panel. This quick shift mode is quite effective for the working conditions where frequent shifting is required.

d) Preset reverse speed function eliminates the need for gearshifting

By turning the reverse speed setting switch located at the right-upper side of the panel, the ratio for the reverse travel speed to the forward travel speed can be changed. Setting a reverse speed appropriate to the work can improve work efficiency. (**Fig. 6**)

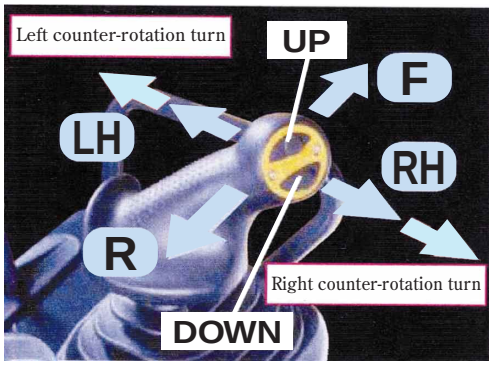
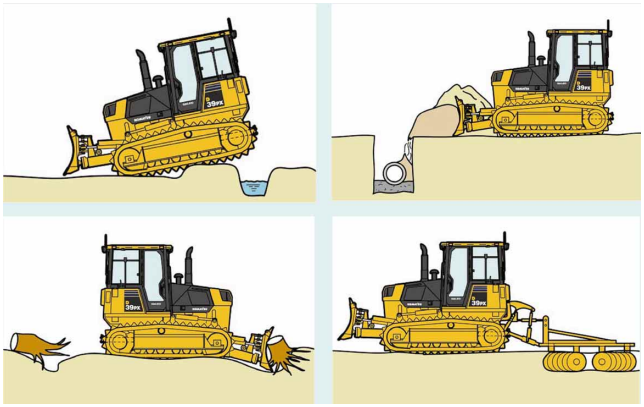


Photo 2 Palm Command Control System (PCCS) joystick



Optimal speed can be freely set to the preference of the operator for crawling, root raking, farming, back filling in pipe laying work. (Example: 2.5th gear speed for rough finishing work)

Fig. 5 Variable speed mode

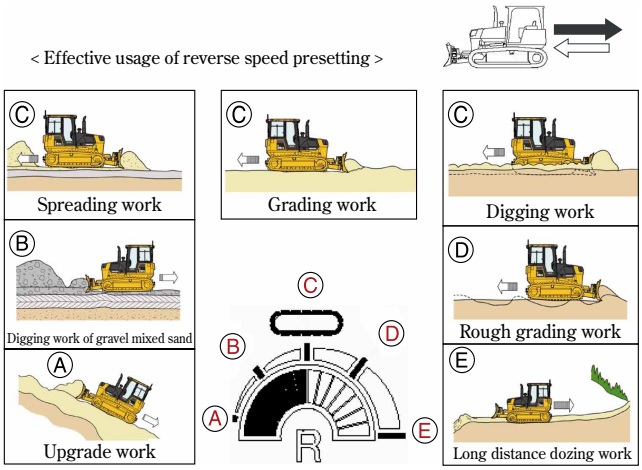


Fig. 6 Reverse speed selection

e) Electronic monitor panel

Indicates set travel speed at the center of the monitor for easier reading. The shift mode switch on the right-hand side can be used to select the desired shift mode with ease.The multi-information display indicates the service meter, replacement times for filters and oil for maintenance. In case of a failure, an action code will be displayed to prompt the operator to take corrective action.When repairing the machine, the monitor panel displays more detailed information to support troubleshooting when switches on the left side of the monitor is operated. (**Photo 3**)

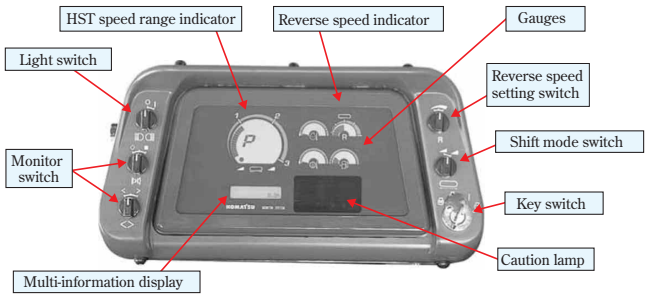


Photo 3 Electronic monitor panel

3) Others

a) Extended service life of blade center ball

The wear life of the ball has been increased by over three times by drastically increasing the diameter of the center ball that supports PAT blade and modifying the structure to the horizontal support. (**Fig. 7**)

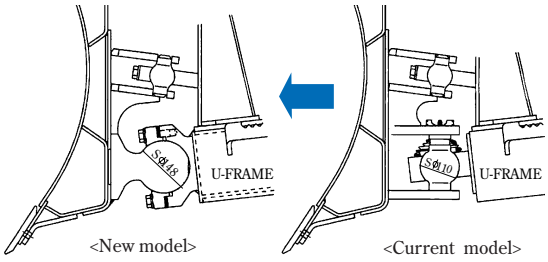


Fig. 7 Blade center ball structure

b) Improved soil rolling-up performance of the blade

The mold board radius is larger, subsequently reducing rolling-up resistance at digging and dozing operation to improve rolling-up performance. (**Fig. 8**)

c) Extended hitch

Rear hitch has been extended by 200 mm providing increased clearance between the towing cable and the shoe plates when making turns while towing.

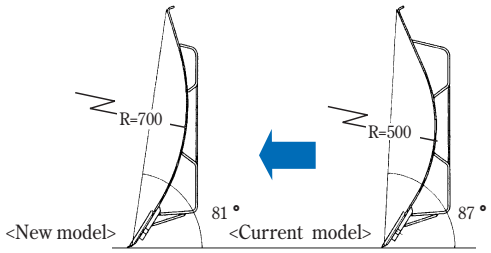


Fig. 8 Improved soil rolling-up performance

4. On closing

Before the formal sales release, "Dozer Day" was held in February 2004 for about one month and attended by some 330 sales representatives from distributors throughout North America. Their evaluation can be summarized into the following six (6) points:

1) Komatsu small-sized crawler dozers have turned into powerful machines . They are a match for competitive machines.
2) Steering is responsive and smooth.
3) Variable and quick shift modes make the machines easier to use.
4) The monitor panel provides easier and more precise reading .
5) The larger center ball can be a big selling point.
6) The soil rolling-up performance of the blade has been much improved.

Also, in March, we held a “Field Day” for users, and in August, we conducted field survey on the machines in operation. To our delight, we received a similar range of comments on both occasions. We were convinced that we could complete the products we can offer with confidence to a number of users, since our development was promoted under our concept of “PIVOT ON THE CUSTOMER.”

Introduction of the writers

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[A few words from the writers]

Planning for this development started in Jan. 2003. Prompted in anticipation of receiving large orders, the development was carried out with unusual speed, and full-scale production began only 14 months after the project was initiated. We realize that this was only possible due to the great combined efforts of the development and manufacturing divisions. Availing themselves of the contribution of this paper, the authors wish to express their appreciation to individuals of the Product Planning Dept., the Test Engineering Center, respective Technical Centers and the Awazu Plant.