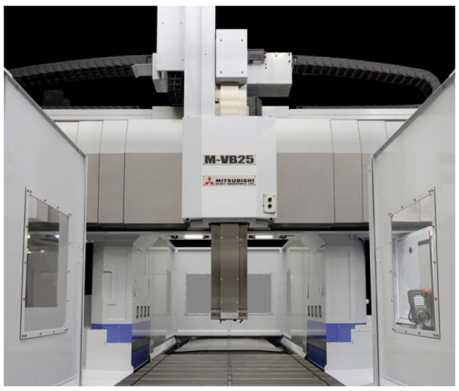
M-VB25 Fixed Rail Bridge Type Milling Machine Series, Best Suited for 5-Face Machining of Thin Workpieces



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In cases mainly for the machining of roughly 500 mm-thick thin workpieces, a fixed rail bridge type milling machine is the best choice in terms of function and cost. But existing machines of the same type do not have sufficient ability to cut at the time of ram extension due to their poor machine stiffness. The developed M-VB25 fixed rail bridge type milling machine has materialized a high-stiffness bridge-shaped strong structure, which has been made to give full play to its high cutting ability at a substantial amount of ram extension. Along with the adoption of an operability-improved/maintenance function-reinforced original control board as well as display, energy saving promotion-based reduction of CO_2 emissions has also been realized. The features of the M-VB25's technology are described below.

1. Introduction

In fields such as industrial equipment, energy and electrical appliances, diversification/division into smaller lots and the upsizing of parts have advanced at processing sites for small and mid-sized product parts in recent years, resulting in more cases where the table size or the stroke amount of each axis is insufficient in existing machining centers. Workpieces of this size are thin, being generally 1 m or more in width and length and 500 mm or less in thickness, and since the installed capacity of a bridge-type 5-face milling machine is too large for the machining of such workpieces with this machine, there is increasing need to reduce investment in equipment by limiting machine functions.

Mitsubishi Heavy Industries, Ltd. (MHI) developed the M-VB25 fixed rail bridge type milling machine, which has a cutting ability sufficient to meet the needs of this market. **Table 1** shows principal specifications. This machine successfully improved machine operability as a solution to increasingly younger operators, and realized a reduction in CO_2 emissions for environmental load alleviation. The features of the M-VB25 are introduced below.

Table 1 M-VB25 specifications

Table	Work surface	Width	mm	1,500
		Length	mm	3,000
	Loading capacity		ton/m	12/3.0
Column bridge width			mm	2,050
Work passage height			mm	1,200
Spindle	Ram size		mm	□350
	Spindle speed		min^{-1}	6,000
Spindle motor output (continuous)			kW	22/30 (low/high speed)
Number of ATC tools			tool (s)	50

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2. Stiffness improvement technology and cutting ability of the M-VB25

A rail-movable (equipped with rail elevating W axis) bridge-type 5-face milling machine represented by MHI's MVR-Ex allows the rail (W axis) to go up and down in accordance with the thickness (height) of the workpiece to be machined, and therefore is characteristically able to set the amount of shortest ram extension (Z axis) for efficient machining. But in the case of a fixed rail (not equipped with rail elevating W axis) 3-axial bridge type milling machines represented by the M-VB25, since it is necessary to machine workpeices only by extending the ram, there was a problem of the failure to obtain sufficient cutting ability due to the larger amount of ram extension for the machining of thin workpieces compared with that of machines with an elevation axis.

Hence, structural reform into a bridge-shaped type was carried out to realize higher stiffness of the machine so that sufficient cutting ability could be ensured even at the time of a substantial amount of ram extension. Through this improvement, MHI commercialized a milling machine with excellent cost performance.

2.1 Stiffness improvement technology

To enhance the cutting ability at the time of ram extension, the rib shape, thickness and layout within the casting structure were optimized, utilizing the latest structure optimization technology along with conventional FEM analysis for successful improvement into a strong bridge-shaped structure with excellent dynamic stiffness.

Figure 1 exemplifies the structural analysis of a bridge-type machine. The latest structural analysis permits the optimum rib structure within the column to be determined. In addition, the M-VB25 adopted an integral column and bridge casting structure to enhance the stiffness at the joints.

Figure 2 shows a photo of the M-VB25's casting structure. Furthermore, casting iron with excellent damping performance was employed for all of its major structures, realizing a vibration-resistant, high-stiffness structure. These stiffness improvement technologies realized a cutting ability 1.4 times greater than before with considerable extension of ram at both the vertical and horizontal spindles.

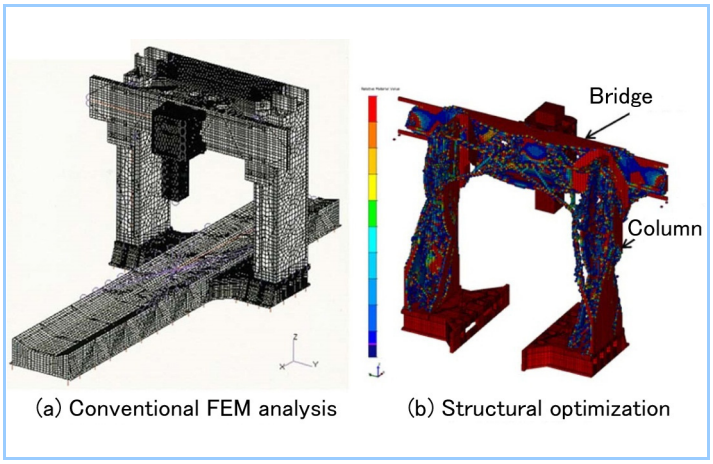

Figure 1 Example of bridge-type machine's structural analysis

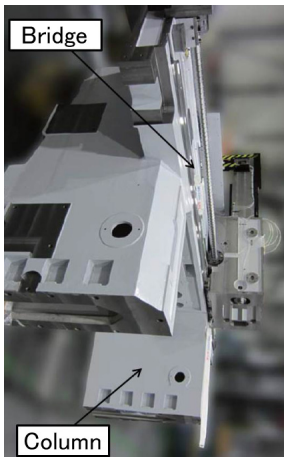

Figure 2 Integrated bridge and column

2.2 Cutting ability

An example of machining where the test piece was SS400 general structural rolled steel, which is used for industrial equipment and other purposes, is introduced here. With this machine, the amount of ram extension at the vertical-axis milling cutter is 919 mm, while that at the horizontal-axis cutter of 631 mm permits heavy cutting of 5-mm cuts. With considerable extension of ram, a cutting ability favorably compared with that of the higher-ranked MVR-Ex has been acquired. **Figure 3** and **Table 2** exemplify milling cutter/endmill processing cases.

Table 2 Cutting ability of the M-VB25

Model	Vertical/ horizontal	Material	Tool	Spindle speed(rpm)	Cutting speed (m/min)	Width of cut (mm)	Depth of cut (mm)	Feed rate (mm/min)	Cut amount (cc)	Ram extension (mm)
M-VB25	Vertical axis	SS400	φ160 face milling cutter	420	211	130	5	1,100	715	919
			φ63 end mill	500	99	25	35	300	263	906
	Horizontal axis		φ160 face milling cutter	420	211	130	5	1,100	715	631
			φ63 end mill	500	99	25	35	300	263	708
MVR-Eχ	Vertical axis Horizontal axis	SS400	φ160 face milling cutter	420	211	130	5	1,100	715	800
			φ160 face milling cutter	420	211	130	4	1,100	572	800

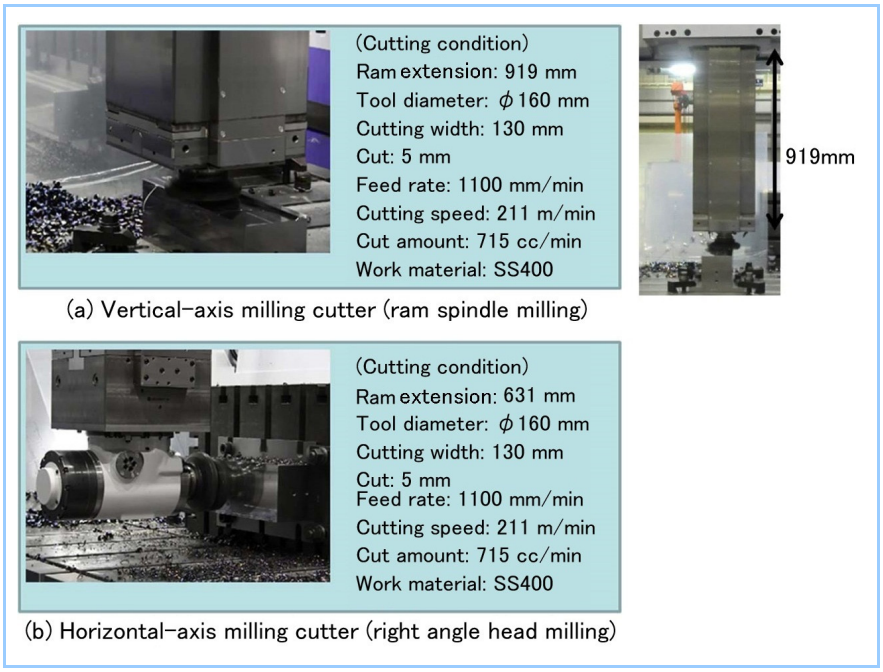

Figure 3 Milling

3. Operability improvement and maintenance function reinforcement of machine

At processing sites, the rate of younger operators is increasing while the number of veteran engineers decreases. In addition, due to the higher performance of machines, their operation and restoration methods are becoming more complex. With these factors in the background, there is growing demand foramachine that dispenses with the need for skill in operation. Customer demands are as follows:

- Touch-panel and other intuitive/simple-to-operate control console/screen
- Control console/screen easy to manually operate during automatic milling in small-lot work processing
- Expansion/facilitated operation of the maintenance functions so that even customers can easily restore the machine.

3.1 Improved operability

Figure 4 illustrates the proprietary control console and operating screen that MHI developed based on customer voices and human engineering. Being enabled with simpler/more intuitive operation compared with that of conventional machines could prevent operators from making mistakes and shorten non-processing time such as keypunching. The features of the developed control console and operating screen are as follows:

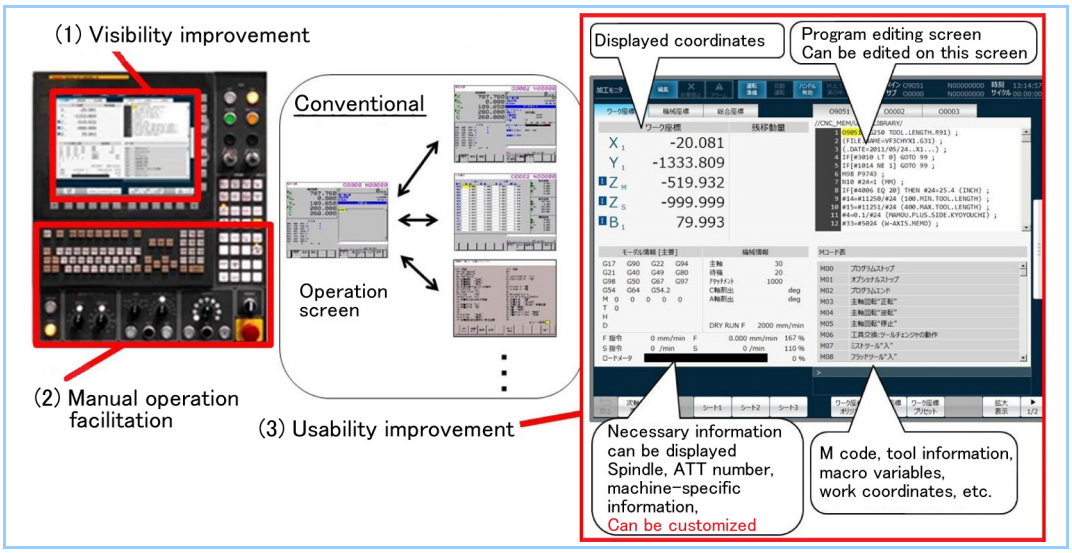

Figure 4 Control console and operating screen

(1) Easier to view
- Operating screen expanded from 10.4 to 15 inches
- Higher visibility of onscreen characters due to font/coloration optimization

(2) Easier manual operation
- Change from the unique key arrangement of the numerical control to that of QWERTY key arrangement identical to a personal computer
- Axis selection and override switches arranged at optimum heights/positions in consideration of operator posture for machine operation

(3) Easier to use
- Changed from single-screen to multi-screen (for coordinates, program, machine-specific and other information) display
- Added function to customize the information to be displayed on a screen (including the selection of information to be displayed)

3.2 Enhanced maintenance function

Due to the increased sophistication of the machinery, it is also necessary to facilitate the operation of maintenance functions including restoration once an alarm is sounded. **Figure 5** compares the M-VB25 with existing equipment in terms of the alarm display screen. Unlike existing equipment using only text display of alarm contents, the M-VB25 provides a 3D birds' eye view of the machine with the alarm location highlighted, etc., realizing the visualization of the equipment for which the alarm has sounded, the cause of the alarm and troubleshooting methods.

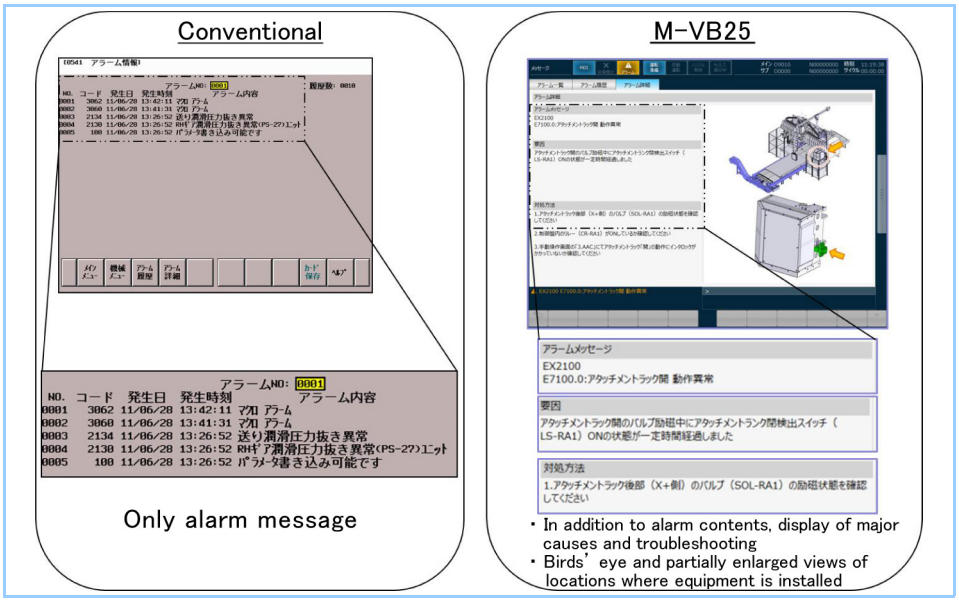

Figure 5 Comparison between alarm display screen of conventional machine and M-VB25 (recovery facilitation)

Alarm fault recovery has also been facilitated. **Figure 6** compares the recovery screen of the M-VB25 with that of existing machines. In existing machines, recovery is based on single M-Code* operation concurrent with consultation with the operation manual, requiring time for the checking of operational procedures and recovery itself. In the case of the M-VB25, the state of the target equipment's actuator/interlock, as well as the recovery procedures, are indicated on the operation screen to eliminate the need to check operational procedures, thereby enabling quick recovery.

* M code: 2 or 3-digit number following M to direct the auxiliary movement of a machine tool

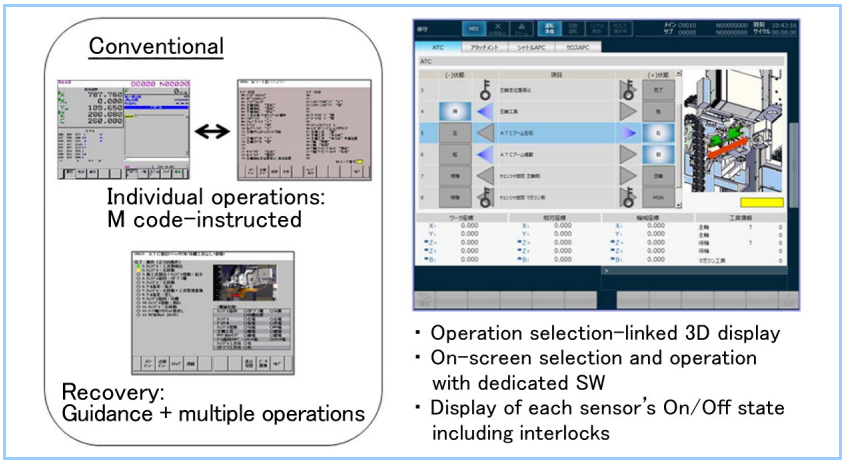

Figure 6 Comparison between recovery screen of conventional machine and M-VB25 (recovery procedure)

4. Power consumption reduction (energy saving) of machine

In the industrial world, a variety of approaches are being intensified to improve the efficiency of energy consumption under the Energy Conservation Act, and there is growing demand to reduce electricity consumption by production equipment including machine tools. Since the energy consumed for the machining of workpeices depends upon the material of the workpiece and cutting conditions including the kind of the tool, it becomes important for energy saving by a machine tool to enhance the efficiency of equipment while the machine is in operation.

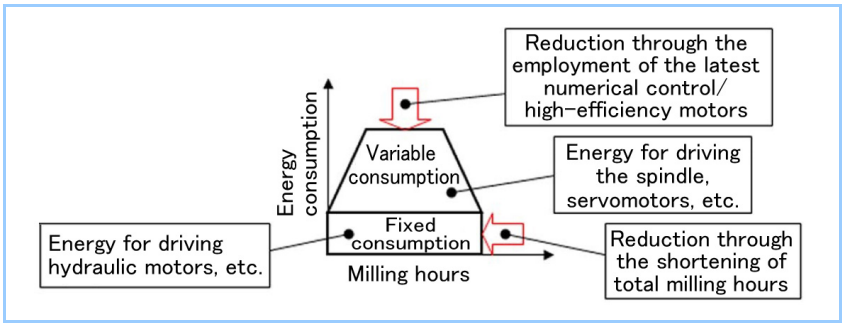

Figure 7 Energy saving measures for machine tools

Figure 7 shows how energy saving measures should be undertaken for machine tools, and **Figure 8** illustrates an example of electricity consumption by existing machines. For the spindle and feed motors with the highest energy consumption share, the latest numerical control technology and high-efficiency motors were adopted, and for the oil cooler/multi-kind pumps as well, high-efficiency equipment complying with the Top Runner Program regulations were adopted, thereby reducing electricity consumption.

For hydraulic motors, lubricating equipment and oil coolers, which regularly consume electricity during machining, an idling stop function to monitor the state of the spindle temperature and the operation state of the machine for automatically halting unnecessary hydraulic, lubricating and cooling operations was developed and mounted on the M-VB25, achieving energy saving of 10% from the level of consumption by existing machines (energy conservation).

- Adoption of the latest numerical control technology/high-efficiency motors (3% reduction in power consumption in MHI's in-house comparison)
- Addition of idling stop function for hydraulic units, oil coolers and lubricating equipment (7% reduction in power consumption in MHI's in-house comparison)

By reviewing operations of tool exchanging and attachment indexing to shorten the operating time, processing hours could be further reduced by 10% in total, thereby reducing fixed energy consumption.

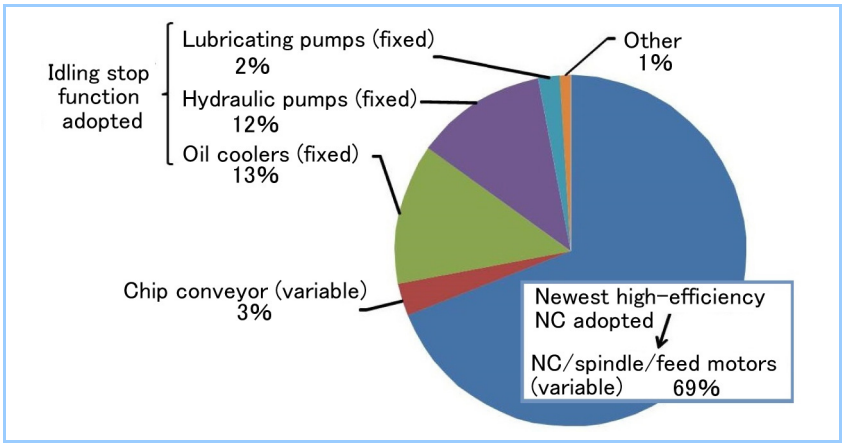

Figure 8 Power consumption of existing machines (example)

5. Conclusion

The newly-developed M-VB25 was designed to feature higher stiffness by applying structural optimization technology, as well as through the integration of the column with the bridge. As a result, a cutting ability as high as 1.4 times that of existing equipment with considerable extension of ram was achieved. At the same time, the maintenance functions were strengthened such as through the improvement of operability and the facilitation of recovery, enabling non-processing time to be shortened. Also, the revision of machine operation and the addition of an idling stop function permitted energy savings of 10% to be achieved in MHI's in-house comparison.