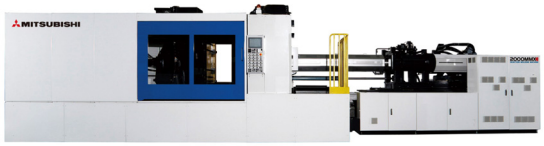
# MMX Series High Accuracy, Energy Saving Large Hydraulic Injection Molding Machines

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To respond to the super-strong yen of recent years and the growing markets of China and other emerging countries, the automotive and light electrical appliance industries have been shifting to global production, where products are produced locally for local consumption. In emerging countries, due to demand for compact cars and low-cost appliances, manufacturing facilities that provide cost savings such as a reduction of plant cost, power consumption and defect rate, are required.

Hydraulic injection molding machines are cheaper than electric injection molding machines, but have the issues of higher power consumption and lower injection accuracy because of the open loop control.

Therefore MHI has developed the MMX series of high accuracy, energy saving large hydraulic injection molding machines equipped with the Smart Pump System, a system that enables higher accuracy and much greater energy savings in comparison with conventional hydraulic injection molding machines. This document describes their features, performance and specifications.

## 1. Features

### 1.1 Features of MMX series

(1) Mechanisms and functions

The MMX series state-of-the-art large hydraulic injection molding machines integrate the Smart Pump System, which uses the latest technologies to attain accurate energy-saving control, long-established proven expertise such as the reliable two platen clamping mechanism, the easy-to-use MAC VIII$^{+}$ operation panel, the long L/D UB screw with high mixing performance and plasticizing capacity and a molding time reduction function. (**Figure 1**)

(2) Safety standards, power supply voltage and man-machine interface for global use

The MMX series is a modular design, allowing it to conform to domestic and foreign safety standards for injection molding machines and power supply voltage specifications, including the general rules of the Japan Society of Industrial Machinery Manufactures' Standards, ANSI (US), CE (Europe), GB (China), KCS (Korea), etc.

The controls consist of a large LCD screen touch panel that displays easy-to-read simple graphics, and has a security function that allows for settings to be changed separately by administrators and operators. Thus easier operation, enhanced operating management and the prevention of malfunctions are realized.

### 1.2 Smart Pump System (international patent pending)

(1) Development of accurate and energy saving control technology for hydraulic pumps

Conventional large hydraulic injection molding machines have multiple fixed pumps corresponding to the maximum load flow that rotate at a constant speed, and return the excessive oil to the tank depending on the oil flow required for the molding process. In this case, the power consumed in pumping the excess oil that is to be returned is wasteful.

Small and mid-sized injection molding machines have a hybrid pump (a speed-controlled fixed pump that uses a servo motor control) for energy saving operation. However, large injection molding machines need a large amount of oil and thus control the combined capacity

of multiple pumps. As described later, a combination of multiple hybrid pumps can cause problems, including unstable injection speed at low rotational speed, too much motor load and shortened service life of the fixed pumps.

Therefore MHI developed the Smart Pump System, which uses a variable discharge pump that features high stability at a lower flow rate as the main pump, and drives it at a constant speed with a highly efficient motor. At the same time, as an enhancing pump, a hybrid pump (consisting of a fixed motor and a servomotor) is also employed. Depending on the speed setting, the Smart Pump System controls the combined capacity by turning on and off the servomotor to change the rotational speed. (**Figure 2**)

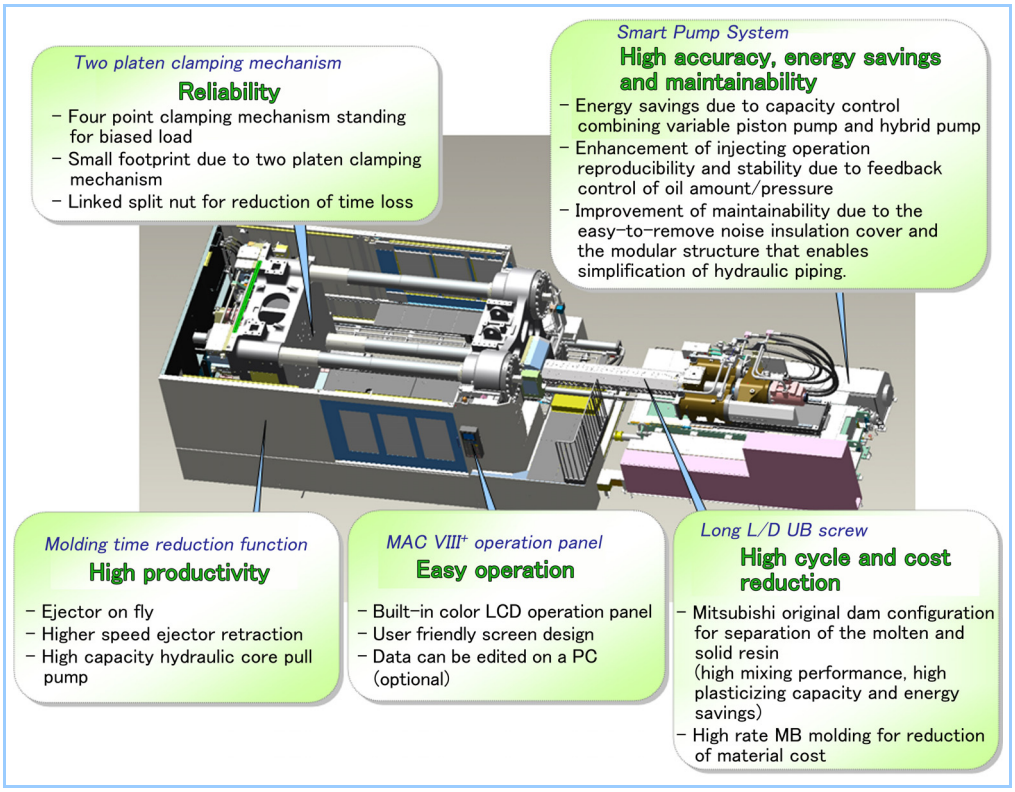


**Figure 1 Features of MMX series**

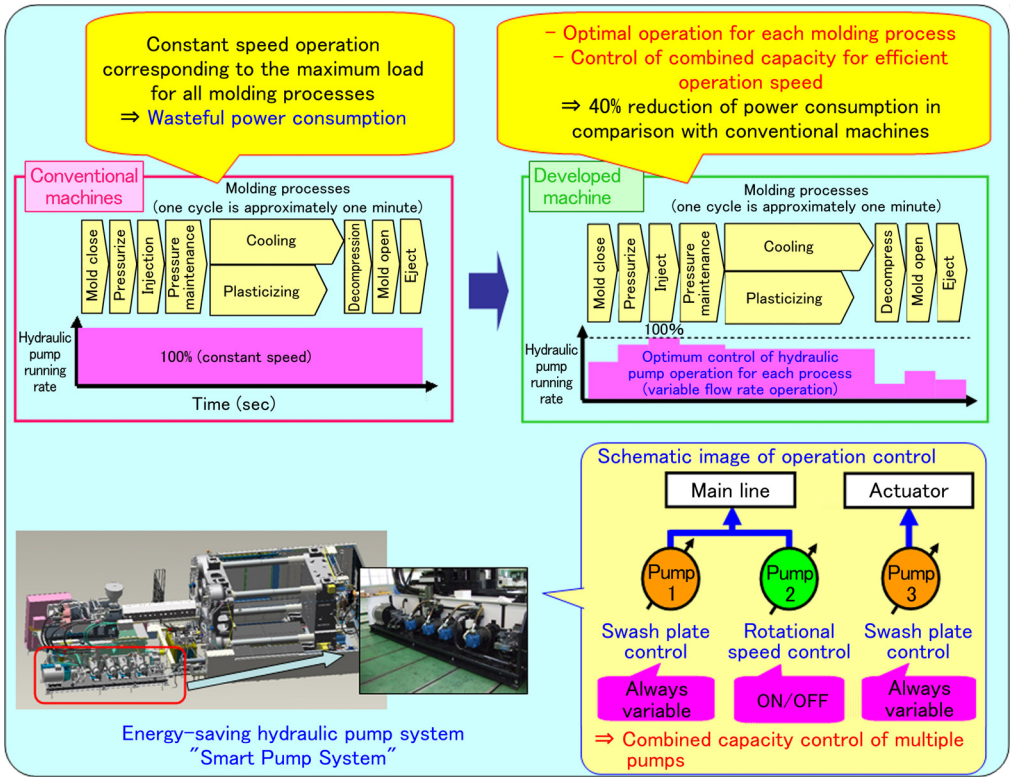


**Figure 2 Smart Pump System**

(2) Energy savings

World-leading energy savings with a 40% reduction of electrical power consumption in comparison with conventional hydraulic injection molding machines is attained by combined capacity control that can use efficient motor rotational speed for each molding processes corresponding to the required oil flow and pressure.

(3) Feedback control of hydraulic oil flow and pressure with improvement of transient response characteristics

To attain higher accuracy, it is necessary to use feedback control of hydraulic oil flow and pressure instead of the conventional open loop control. However, because of differing frequency characteristics between pumps, overshoot or undershoot of flow rate occurs when the hybrid pump is turned on or off, and this results in unstable injection accuracy. To resolve this problem, control parameters are adjusted by coupled simulation of hydraulic and power/control systems so that the transient response characteristics of the variable discharge pump and the hybrid pump become uniform. Due to suppression of the overshoot or undershoot of flow rate, injection accuracy has improved and stable molding quality has been attained.

(4) Comparison with multiple hybrid pump system

The combination of multiple hybrid pumps, during operation at lower rotational speeds, presents problems such as shortened service life and/or lowered injection speeds due to wear of the fixed pump and overload of the servomotor.

The Smart Pump System, operating at a lower flow rate, stops the enhancing pump and controls the flow rate and pressure through the use of the variable discharge pump and the high-efficiency motor. This prevents heat and wear caused by lubrication failure of the fixed enhancing pump, and allows speed lowering to be suppressed and the fixed pump's life to be extended. In addition, overload of the servomotor during long periods of high pressure is prevented, and thus high-load molding can be attained. (**Figure 3**)

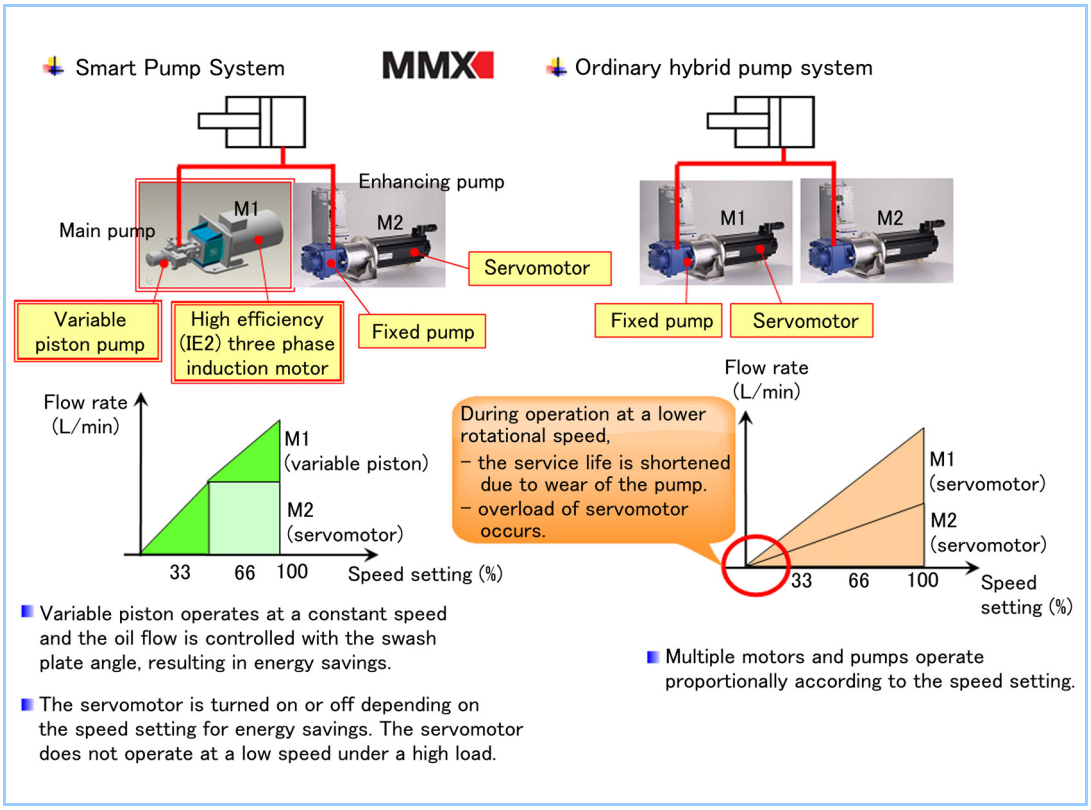


**Figure 3 Comparison between Smart Pump System and hybrid pump system**

(5) Noise reduction and improvement of maintainability

For clean operation, maintainability and low noise, which are issues of conventional machines, the following improvements were made to the MMX series.

(i) The noise insulation cover consists of multiple pieces for easy removal. The cover is mounted on the machine by simply hanging its top and attaching its bottom, and thus it can be removed by holding the handle on the slant face cut out along the direction for removal and swinging it up using the bottom as a fulcrum.

(ii) All pumps are covered by noise insulation covers on which noise absorbing material is attached, resulting in significantly lower noise levels in comparison with conventional machines.

(iii) Both the clamping unit and the injection unit have their own oil tank, and a modular structure including the hydraulic oil piping is established. This makes the hydraulic oil piping layout simpler and installation/maintenance easier. (**Figure 4**)

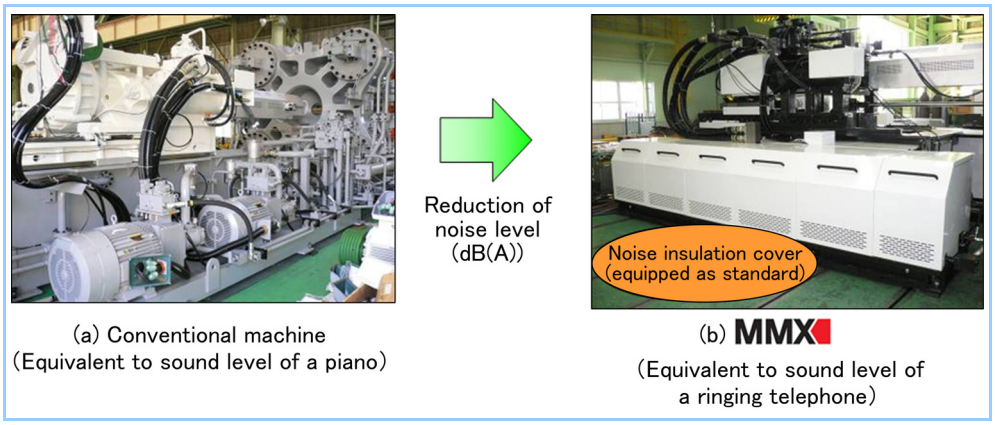


**Figure 4 Noise insulation cover (Noise reduction and improvement of maintainability)**

## 2. Specifications

The specifications of the MMX series are shown in **Table 1**.

**Table 1 Specifications of the MMX series**

| | Model | | | 1,300MMX | | | 1,600MMX | | | 2,000MMX | | | | 2,500MMX | | | 3,000MMX | | 3,500MMX | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Units) | 160 | 240 | 340 | 240 | 340 | 470 | 240 | 340 | 470 | 740 | 340 | 470 | 740 | 470 | 740 | 470 | 740 |
| Injection Unit | Screw Diameter | | mm | 105 | 120 | 135 | 120 | 135 | 150 | 120 | 135 | 150 | 175 | 135 | 150 | 175 | 150 | 175 | 150 | 175 |
| | Theoretical Injection Volume | | $cm^3$ | 4,540 | 6,780 | 9,660 | 6,780 | 9,660 | 13,200 | 6,780 | 9,660 | 13,200 | 21,000 | 9,660 | 13,200 | 21,000 | 13,200 | 21,000 | 13,200 | 21,000 |
| | Injection Shot Mass | PS | g | 4,180 | 6,240 | 8,890 | 6,240 | 8,890 | 12,100 | 6,240 | 8,890 | 12,100 | 19,300 | 8,890 | 12,100 | 19,300 | 12,100 | 19,300 | 12,100 | 19,300 |
| | | PE | | 3,360 | 5,020 | 7,150 | 5,020 | 7,150 | 9,770 | 5,020 | 7,150 | 9,770 | 15,500 | 7,150 | 9,770 | 15,500 | 9,770 | 15,500 | 9,770 | 15,500 |
| | Max. Injection Pressure | | MPa | 177 | | | 177 | | | 177 | | | 161 | 177 | | 161 | 177 | 161 | 177 | 161 |
| | | | $kgf/cm^2$ | 1,800 | | | 1,800 | | | 1,800 | | | 1,640 | 1,800 | | 1,640 | 1,800 | 1,640 | 1,800 | 1,640 |
| | Injection Speed | | mm/sec | 106 | 97 | 88 | 97 | 88 | 76 | 97 | 88 | 76 | 66 | 88 | 76 | 66 | 76 | 66 | 76 | 66 |
| | Injection Rate | | $cm^3$/sec | 920 | 1,095 | 1,260 | 1,095 | 1,260 | 1,350 | 1,095 | 1,260 | 1,350 | 1,595 | 1,260 | 1,350 | 1,595 | 1,350 | 1,595 | 1,350 | 1,595 |
| | Plasticizing Capacity (Ps) | | kg/hr | 580 | 655 | 700 | 655 | 700 | 750 | 655 | 700 | 750 | 805 | 700 | 750 | 805 | 750 | 805 | 750 | 805 |
| | Screw Speed | | rpm | 139 | 112 | 112 | 112 | 112 | 110 | 112 | 112 | 110 | 90 | 112 | 110 | 90 | 110 | 90 | 110 | 90 |
| Clamp Unit | Max. Mold Clamping Force | | kN (tf) | 12,748 (1,300) | | | 15,690 (1,600) | | | 19,613 (2,000) | | | | 24,516 (2,500) | | | 29,419 (3,000) | | 34,323 (3,500) | |
| | Mold Opening Force | | kN(tf) | 980 (100) | | | 1,225 (125) | | | 2,059 (210) | | | | 2,059 (210) | | | 2,353 (240) | | 2,353 (240) | |
| | Mold Closing Speed (High) | | m/min | 45 | | | 45 | | | 45 | | | | 45 | | | 45 | | 45 | |
| | Mold Opening Speed (High) | | | 45 | | | 45 | | | 45 | | | | 45 | | | 45 | | 45 | |
| | Platen Size H×V | | mm | 2,000×2,000 | | | 2,500×2,000 | | | 2,500×2,250 | | | | 2,550×2,300 | | | 2,550×2,500 | | 2,550×2,500 | |
| | Clearance Between Tie Bars H×V | | mm | 1,450×1,400 | | | 1,850×1,520 | | | 1,850×1,650 | | | | 2,000×1,650 | | | 2,050×1,900 | | 2,050×1,900 | |
| | Max. Clamp Stroke | | mm | 2,150 | | | 2,450 | | | 2,500 | | | | 2,800 | | | 3,200 | | 3,200 | |
| | Max. Daylight | | mm | 2,800 | | | 3,200 | | | 3,250 | | | | 3,600 | | | 4,200 | | 4,200 | |
| | Mold Height | | mm | 650～1,300 | | | 750～1,500 | | | 750～1,500 | | | | 800～1,700 | | | 1,000～1,900 | | 1,000～1,900 | |
| | Ejector Force | | kN(tf) | 294 (30) | | | 294 (30) | | | 392 (40) | | | | 490 (50) | | | 490 (50) | | 490 (50) | |
| | Ejector Stroke | | mm | 300 | | | 300 | | | 350 | | | | 400 | | | 400 | | 400 | |
| General | Electric Motor Capacity | | kW | 123 | 146 | 169 | 146 | 169 | 192 | 146 | 169 | 192 | 215 | 177 | 200 | 223 | 200 | 223 | 200 | 223 |
| | Electric Heater Capacity (380v/50hz) | | | 50.7 | 53.5 | 67.5 | 53.5 | 67.5 | 84.8 | 53.5 | 67.5 | 84.8 | 111.7 | 67.5 | 84.8 | 111.7 | 84.8 | 111.7 | 84.8 | 111.7 |
| | Total Hyd. System Oil Quantity [In Tank] | | L | 2,200 [1,700] | 2,500 [2,000] | | 2,600 [2,000] | | 3,100 [2,500] | 2,600 [2,000] | | 3,200 [2,500] | 3,900 [3,100] | 2,600 [2,000] | 3,200 [2,500] | 3,900 [3,100] | 3,700 [2,630] | 4,400 [3,230] | 3,700 [2,630] | 4,400 [3,230] |
| | Overall Dimension | L | m | 11.3 | 12.0 | 12.2 | 12.6 | 12.8 | 13.9 | 13.0 | 13.1 | 14.3 | 14.6 | 13.9 | 15.0 | 15.3 | 15.8 | 16.1 | 15.8 | 16.1 |
| | | W | m | 3.5 | | | 3.9 | | | 4.0 | | | | 4.3 | | | 4.8 | | 4.8 | |
| | | H | m | 3.2 | | | 3.3 | | | 3.4 | | | | 3.5 | | | 3.9 | | 3.9 | |
| | Shipping Mass | | ton | 63 | 66 | 69 | 81 | 84 | 90 | 93 | 96 | 102 | 111 | 118 | 124 | 132 | 153 | 162 | 153 | 162 |

*Above value is common to 50Hz and 60Hz. (The electric heater capacity is an exception.)

*Above value includes the planned value, and subject to change due to modification without prior notice.