Large Gear-grinding Machine “ZGA2000” and Large Gear-hobbing Machine “GEA1200”, Providing High-efficiency Production for Large-part Manufacturers

Sales Department
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There has recently been an increased demand for machining large gears for use in wind turbine gearboxes, mining equipment, and so on. Although the demand for large-gear machines declined after Lehman's fall, it is expected to pick up as the demand for wind turbine generators and construction equipment recovers. While most gear machines manufactured by Mitsubishi Heavy Industries, Ltd., (MHI) have so far been for automotive products, the company intends to actively develop the market for larger-gear machines in order to win more orders. MHI developed the large gear-grinding machine “ZGA2000” and the large gear-hobbing machine “GEA1200” as products that can provide highly efficient, highly accurate machining. These machines are outlined below.

1. Outline of the ZGA2000 Large Gear-grinding Machine

1.1 Specifications

The main specifications of the gear-grinding machine are given in **Table 1**.

Table 1 Main specifications of the large gear-grinding machine

Items	Unit	New model ZGA2000	Existing model ZG1000CNC
Workpiece max. diameter	φmm	2,000	1,000
Max. module	mm	36 (whole depth: 80)	18 (whole depth: 45)
Grinding wheel max. diameter	φmm	400	300
Grinding wheel rotation	Min^{-1}	200 – 5,200	200 – 4,000
Axial stroke	mm	700 (OP 1,400/1,800)	700
Radial stroke (Distance between grinding wheel and workpiece)	mm	1,040 300 – 1,340	615 100 – 715
Table max. weight	t (ton)	20	5
Machine layout (Width × depth × height)	mm	6,210 × 8,620 × 5,900	4,215 × 5,530 × 3,580

1.2 Features

The ZGA2000 is a gear-grinding machine capable of handling workpiece diameters up to 2,000 mm. A high machining accuracy is required during the gear-grinding process. In this process, the tooth surfaces of a gear are ground after heat treatment. For highly accurate and efficient machining, the ZGA2000 uses built-in motors for the wheel and dress spindles, and a direct drive motor and high-stiffness hydrostatic bearing for the worktable spindle. As a result, it can reduce the machining time by 20% compared to the existing ZG1000 model, and has achieved a machining accuracy compliant with Class 1 or higher, according to the new Japanese Industrial Standards (JIS). Furthermore, to reduce the downtime, MHI strove to increase the speed and accuracy of the on-machine gear inspection device. As shown in **Figure 1**, MHI succeeded in reducing the travel distance from the tooth root to the tip of a contact probe during tooth profile measurement, thereby improving the efficiency with which the machine can be controlled and checked.

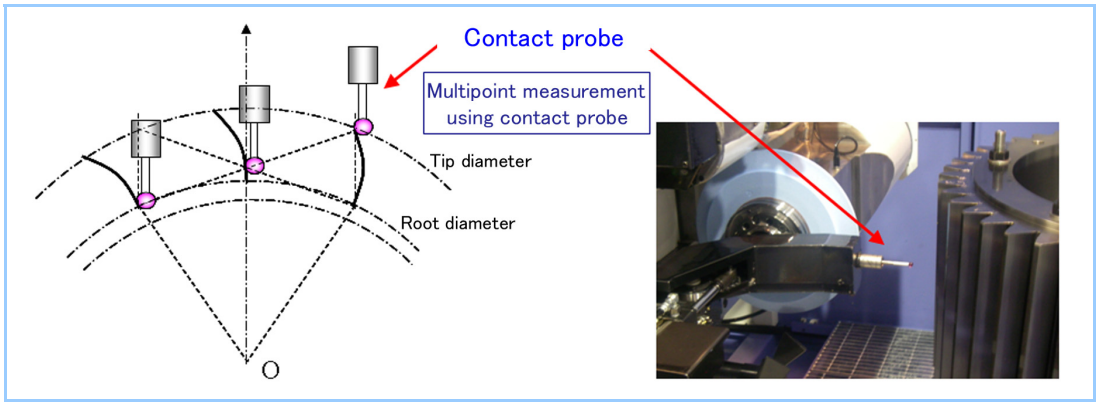

Figure 1 On-machine gear inspection device

2. Outline of the GEA1200 Large Gear-hobbing Machine

2.1 Specifications

The main specifications of the gear-hobbing machine are given in **Table 2**.

Table 2 Main specifications of the large gear-hobbing machine

Items	Unit	New model GEA1200	Existing model GB100CNC
Workpiece max. diameter	φmm	1,200	1,000
Max. module	mm	20 (OP 30)	14
Hob max. diameter × length	φmm	φ350 × 450 (OP φ500 × 500)	φ210 × 240
Hob rotation	Min^{-1}	25 – 250	30 – 225
Axial stroke	mm	700(OP 1,400/2,000)	500
Radial stroke (Distance between hob and workpiece)	mm	950 110 – 1,060	575 50 – 625
Table max. weight	t (ton)	15	3
Machine layout (Width × depth × height)	mm	5,800 × 6,550 × 5,300	4,400 × 3,252 × 3,410

2.2 Features

The GEA1200 is a gear-hobbing machine capable of handling workpiece diameters up to 1,200 mm. A gear-hobbing machine cut gears by generating process with the use of a cutting tool (hob) that is threaded with respect to the main spindle. The machine is required to efficiently cut gears with a high degree of accuracy. The GEA1200 incorporates a motor with a rated output of 30 kW for the main spindle and a triple-lever clamping mechanism to enhance the hob clamping force, thereby improving the stiffness of the hob head. Similar to the ZGA2000, MHI adopted a high-stiffness hydrostatic bearing for the worktable spindle and employed a double worm backlash eliminator to enable stable heavy cutting. MHI also modeled the entire machine (**Figure 2**) and used a static and dynamic stiffness analysis technique based on three-dimensional finite element modeling (FEM) to optimize the rib layout. This provides an optimum design with a high degree of stiffness, while reducing the component weight. As a result, the GEA1200 can reduce the machining time by 30% compared to the existing model, GB100, and has achieved a machining accuracy compliant with Class 5 or higher according to new Japanese Industrial Standards (JIS).

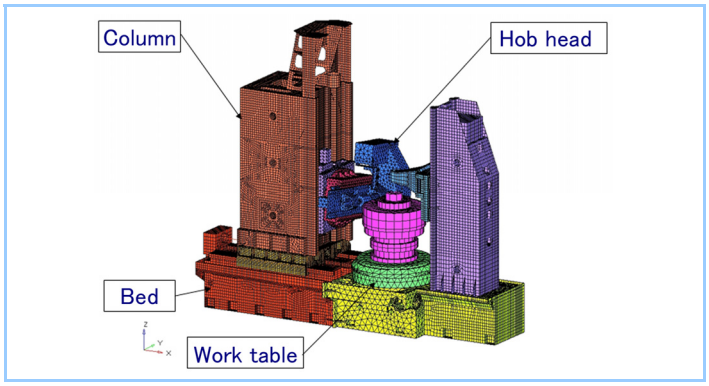

Figure 2 Three-dimensional FEM analysis model

3. Future Developments

When developing large gear machines, MHI has focused on the creation of a modular design applicable to different types of equipment, such as gear-hobbing, gear-shaping, and gear-grinding machines. MHI has adopted a basic machine structure capable of handling maximum workpiece diameters ranging from 1,200 to 4,000 mm. This makes it possible to quickly deliver a machine after an order has been placed. The large gear-grinding machine "ZGA2000" and the large gear-hobbing machine "GEA1200" outlined in this paper have already been delivered to users in Japan. MHI is currently manufacturing the SEA1600, a large gear-shaping machine that can handle workpiece diameters up to 1,600 mm. The company intends to appeal to Japanese users as a manufacturer that can provide reliable services and maintenance in the event of machine failure. At the same time, the company will vigorously focus on sales to customers outside of Japan, based on its overseas outlets in the US, China, and other countries.