

Challenge to Zero - Gear Grinder ZE16C/26C for High Accuracy and Efficiency



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Efficiency improvement and vibration reduction of transmissions have been in demand with the increasing need for low fuel consumption and low noise of automobiles in recent years. As a result, demand for the precision improvement of transmission gears and the stability of grinding accuracy in mass production is increasing. In addition, automobiles are becoming significantly quieter as they proceed with electrification, so greater quietness is also required for transmissions. Generally, gears are subjected to heat treatment of the tooth flank to harden the surface and improve wear resistance and strength. However, heat treatment causes distortion of the tooth flank, resulting in the deterioration of tooth flank accuracy. For this reason, gear grinding after heat treatment is widely used for improving gear accuracy and stabilizing quality.

Mitsubishi Heavy Industries Machine Tool Co., Ltd. developed the ZE16C and ZE26C, a series of gear grinding machines that adopt our proprietary gantry-type counter column structure. This paper presents these products.

1. Features of ZE16C/26C gear grinding machines

1.1 High-precision gear grinding

Mainstream gear grinding machines for mass production are continuous generation types that grind tooth flanks using a thread grinding wheel. In the case of this method, the threaded grinding wheel and the gear to be ground rotate synchronously at high speed in accordance with the ratio of the number of teeth, making high-precision and high-efficiency grinding possible. The grinding accuracy of a gear is usually evaluated based on the error of the tooth profile and tooth helix and pitch error. However, since even a very small amount of undulation of a tooth flank at a micron level influences the vibration and noise at meshing of the gears, minute undulation is also evaluated for higher-precision gears. Therefore, this machine adopts a revised-structure spindle to achieve the enhancement of the static rigidity by 50% and the dynamic rigidity by 35% compared with our conventional machine and realize the improvement of the grinding accuracy and tooth flank undulation.

1.2 Improvement of productivity

Gear grinding requires non-machining time (waste time) for processes such as for clamping, unclamping, and replacing the gear to be ground, tooth meshing between the grinding wheel and the gear to be ground, and dressing the grind wheel. To improve productivity, it is important to shorten this non-machining time. For this reason, the ZE16C adopted our proprietary gantry-type counter column structure to attain high-speed workpiece changing operation and tooth meshing operation (**Figure 1**). By adopting this gantry-type counter column structure, the adoption of a high-speed work changer is made possible and the grinding wheel dressing device is allowed to have a structure for moving up and down on the counter column side face. This structure enabled the reduction of the machine bed length by 20% compared with the conventional machine and realized space saving.

In addition, by placing the non-contact sensor for tooth meshing on the counter column side closer to the gear to be ground and increasing the table rotation speed at the time of detection, the

operation time of tooth meshing can be shortened (**Figure 2**). As a result, in the case of a ring type workpiece, for example, the time for changing the workpiece and tooth meshing is reduced from the conventional 17 seconds to less than half, or 6 seconds. By combining the reduction of non-machining time, the increase of the rotation speed of the grinding wheel axis, and the extension of the grinding wheel life due to enlarging its width, the productivity can be improved by 20% or more in comparison with the conventional machine. **Table 1** shows the machine specifications of the developed ZE16C and ZE26C gear grinding machines. The ZE16C can grind gears up to $\phi 160$ mm, and the ZE26C can grind a wide range of gears up to $\phi 260$ mm with high accuracy and high efficiency.

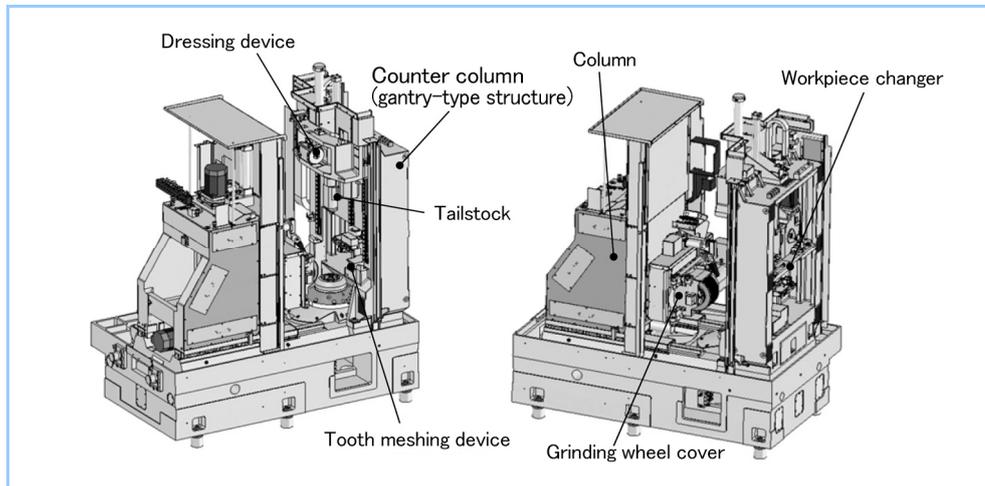


Figure 1 Machine structure (ZE16C)

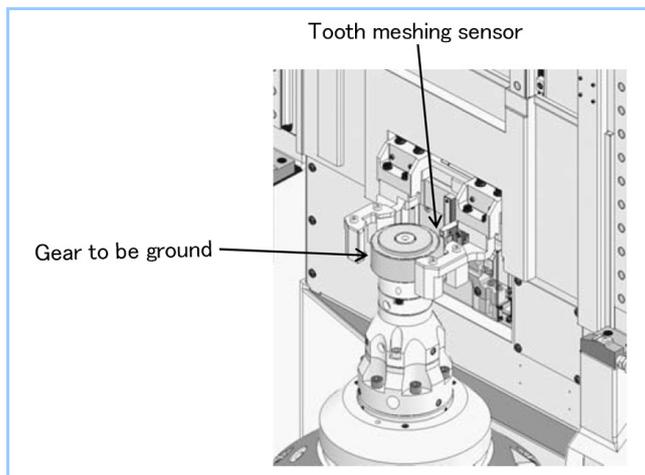


Figure 2 Tooth meshing sensor and gear to be ground

Table 1 Gear grinding machine ZE16C/26C specifications

Specifications	ZE16C	ZE26C
Workpiece diameter	20-160mm	20-260mm
Module	1-4	1-6
Workpiece length	200mm	350mm
Workpiece rotation speed	Up to 3,000min ⁻¹	Up to 2,000min ⁻¹
Grinding wheel diameter	Up to 300mm	
Grinding wheel width	Up to 160mm	
Grinding wheel rotation speed	Up to 8,000min ⁻¹	

2. Grinding example

Figure 3 shows a gear ground by the ZE16C gear grinding machine. A gear with module of 3, 31 teeth, a helix angle of 20°, an outer diameter of 105 mm, and a tooth width of 40 mm was ground with a cycle time of 49.5 seconds, and the grinding accuracy of JIS N1 class was attained. This indicates that this machine is capable of mass production of high-precision gears.

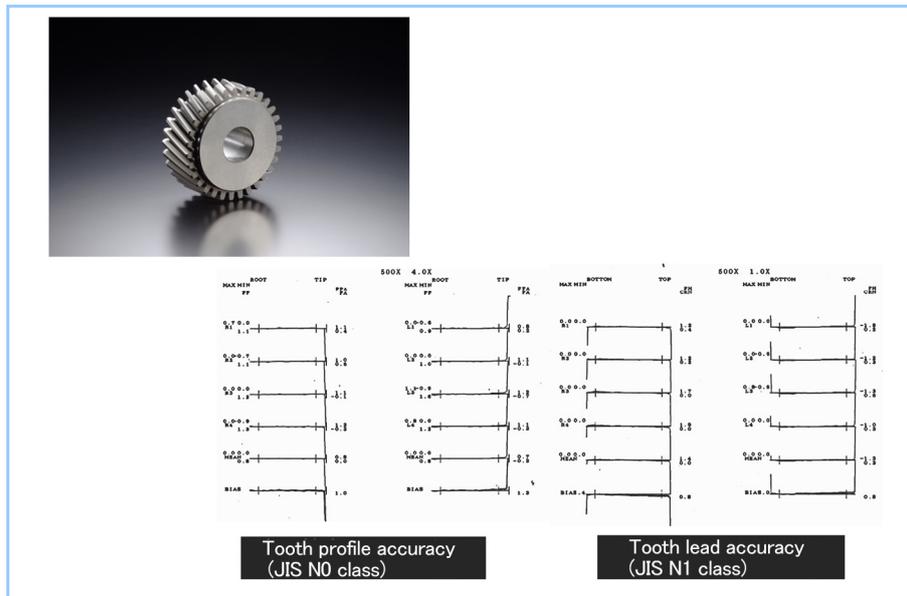


Figure 3 Grinding example (ground gear)

3. Future progress

As automotive fuel efficiency regulations are becoming stricter and powertrains are being electrified, it is believed that the tendency toward higher accuracy and higher efficiency of transmission gears will continue. The ZE16C/26C gear grinding machines were developed under the concept of "challenge to zero – zero tooth flank undulation, zero waste time in grinding, and zero downtime." In the future, we will advance product development to meet customer needs through efforts to reduce the environmental impact of machinery such as the adoption of water-soluble coolant, and the realization of supported machining operation not requiring skill, machine status monitoring, preventive maintenance, etc.