Development of the GC20Mi CBN Cam Grinder

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The GC20Mi CBN cam grinder was developed to meet the need for technological innovativeness, high productivity, and high accuracy stability in CBN cam grinders for grinding automobile camshafts. The GC20Mi is belt-driven, with wheel diameter specifications of u350-120 m/s, u100-60 m/s and u150-80 m/s, and supports direct drive with wheel diameter specifications of up to u350-160 m/s. This enables users to choose the equipment best suited for the target camshaft type. Furthermore, this grinder is equipped with the latest technological elements, and was developed with careful consideration to operability and safety, as well as environmental friendliness.

***Key Words**: cam grinder, reduction of heat distortion, stable accuracy, operability, safety*

1. Introduction

In recent years, as needs for fuel-efficient and low-cost cars grow, automakers have been bringing a series of new products that respond to the needs to market. While electric vehicles (EV) and hybrid vehicles (HV) are receiving attention, cars downsized for fuel efficiency and equipped with a highly efficient engine still represent the majority.

Due to these backgrounds, there is an increasing need for high productivity, stable machining accuracy, and high machining surface quality from carmakers and manufacturers specializing in camshafts. To respond to this need, we have developed the GC20Mi CBN cam grinder (this machine) as a successor of the conventional machine GC20M so that CBN wheels and transfer units can be newly developed and equipped, in cooperation with JTEKT group companies. The overview of this machine follows (**Fig. 1**).

Fig. 1 GC20Mi CBN cam grinder

2. Aim of the development

JTEKT released the GC20M-63 CBN cam grinder in 2005 under the concept of "optimal equipment suitable for camshaft grinding" and has gained a high reputation in the market. More than 8 years have passed, however, since the machine was developed, and it is losing its edge against competitors' machines.

This machine adopts the basic unit, for which high reliability has been proven with GC20M-63. We have improved its raw performance by implementing the latest technological elements and utilizing CAE analysis and given it a facelift to achieve a texture consistent with its quality. Since machines other than high surface speed and high output machines are conventionally used, customers need to prepare maintenance parts for each machine. We have developed this machine with an aim to maintain its superiority over competitors' machines by incorporating high surface speed and high output functions.

3. Features of this machine

①High accuracy and no need to compensate dimensions

In camshaft grinding, workpieces are grinded by simultaneously controlling two axes that advance/retract the wheelhead and rotate the spindle (workpiece).

In order to grind cams with high accuracy, the wheelhead needs to follow the workpiece rotation without delay. As a wheelhead feed mechanism for this machine, we have adopted a system driven by a linear motor consisting of a static pressure slide without friction, achieving high tracking performance, eliminating the need for feed screws and bearings, and securing long-term stability.

Furthermore, the ribs of the bed, a machine base, have been optimally arranged based on CAE analysis, minimizing the effects of thermal displacement of the workpiece support point and grinding wheel position as much as possible.

In addition, by cooling the heat generated by grinding and quickly releasing the heated coolant without keeping it in the bed, thermal displacement has been reduced by approximately 40% per shift (8 hours) compared with the conventional machine (**Fig. 2**). Dimensions are conventionally compensated in the production line during a quality check as necessary, but this machine only requires an initial product check, thus improving productivity.

②High productivity

As a grinding wheel spindle drive system, this machine employs a belt drive system, which has been conventionally used, with a wheel surface speed of 120 m/s. As an optional specification, a direct drive system featuring a built-in motor with a wheel surface speed of 160 m/s is provided so that workpieces can be grinded in optimal grinding conditions according to workpiece materials.

The wheel spindle of the direct drive system has a compact and high output motor with an instantaneous maximum output of 85 kW for high efficiency. In addition, the motor is optimally arranged utilizing CAE analysis to suppress the distortion of the wheel spindle caused by the motor heat (**Fig. 3**).

Grinding performance that suppresses the effects of the vibration caused by the wheel rotation frequency has been achieved through a low vibration bed and "Tough Vi-F" (**Fig. 4**), a CBN wheel developed by JTEKT group company Toyoda Van Moppes Ltd., that has balanced cutting quality and service life, achieving high efficiency (approximately 60%) and cycle time reduction (▲ approximately 15%).

③ Operability and safety

JTEKT started to develop control units in the 1970s and has made a series of improvements so that machines will be easy to use and achieve full performance as control units made by a machine manufacturer. GC20Mi is equipped with a newly developed TOYOPUC®-GC70, achieving 5 times faster calculation speed and 10 times faster communication speed, with a substantial reduction in size.

In addition to the conventional easy-to-use touch panel system, global specifications including icons that enable intuitive operation and language settings that can be easily changed allow the smooth start-up of a production line abroad, etc.

There are functions for safety. Specifically, when the machine is manually operated by the handle, the motion direction is displayed before the operation to prevent erroneous operation, and when the initial workpiece is grinded after a workpiece setup change, the wheelhead slows down near interference objects to assist in checking the operation through the grinding of the initial workpiece (**Fig. 5**).

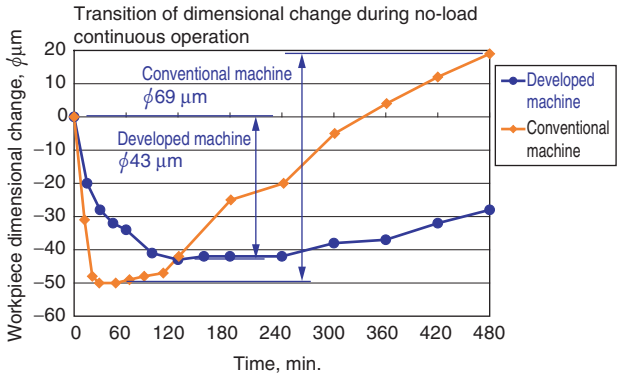

Fig. 2 Transition of dimensional change of workpiece

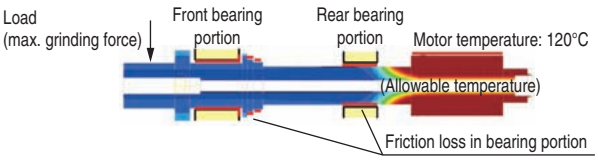

Fig. 3 CAE analysis of wheel spindle

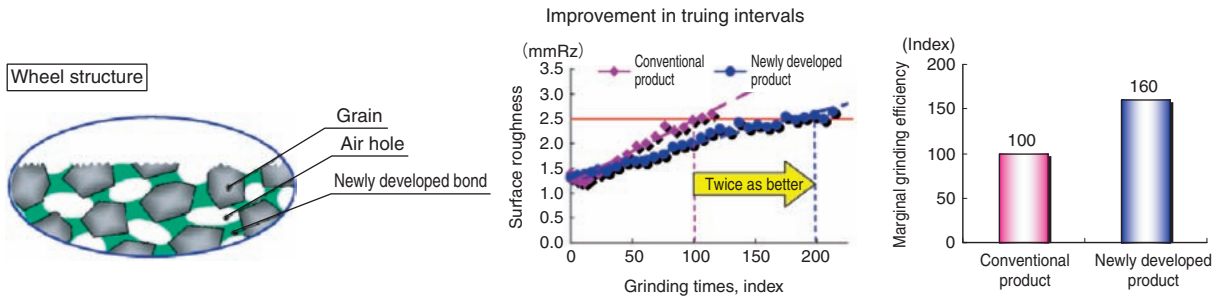

Fig. 4 Tough Vi-F CBN wheel

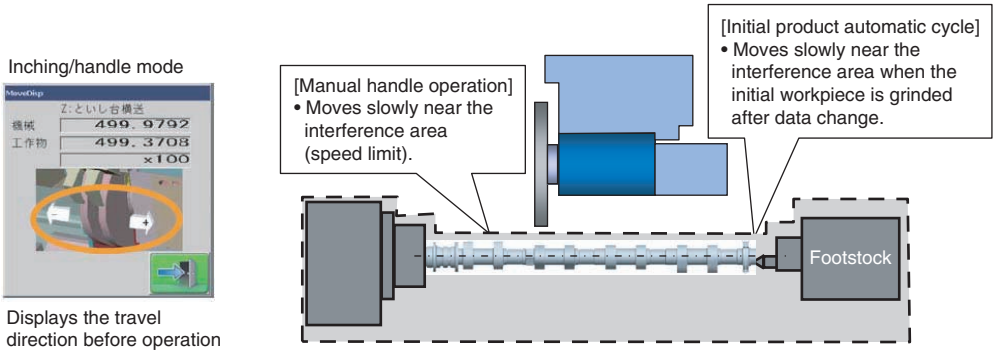

Fig. 5 Safety operation function

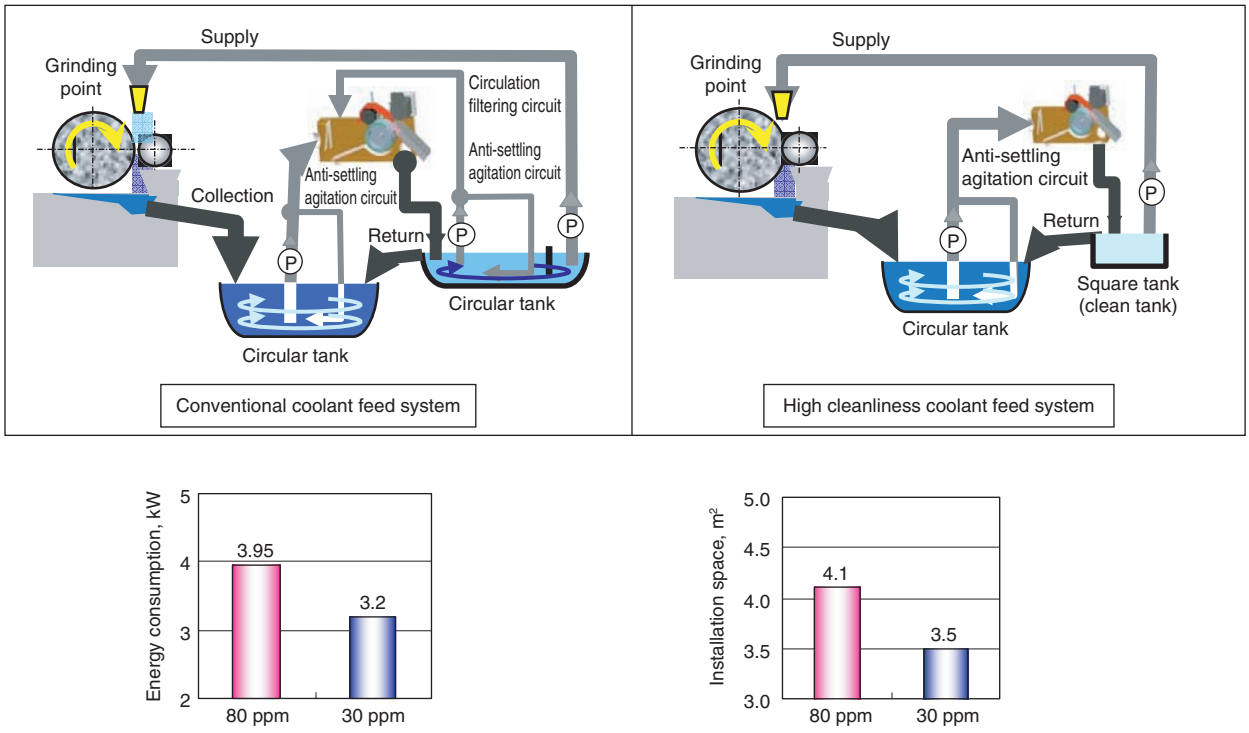

Fig. 6 High cleanliness factor coolant feed system

④ Energy conservation

A coolant supply unit is required for a grinder to remove the heat generated by grinding, discharge cutting chips from the machine, and dispose of them. Stock removal is significant in camshaft grinding, resulting in a large amount of chips, therefore if chips are not properly disposed of, problems including the scratching of workpieces, inaccuracy caused by entangled chips when a workpiece is clamped, overflow of coolant due to accumulated chips in the machine, and failure of devices may occur. A system that circulates coolant to a magnetic separator using a circular tank of the coolant supply unit is conventionally used, but GC20Mi has adopted a high cleanliness factor coolant feed system with a new magnetic circuit developed by JTEKT (**Fig. 6**). This has substantially reduced residual foreign particles in coolant from 80 ppm to 30 ppm. High cleanliness with 30 mg of foreign particles per liter of coolant has been achieved, reducing scratches and greatly extending the coolant replacement intervals. Moreover, the new system is energy-saving and environmentally-friendly as the pump used for the conventional circulation system is no longer necessary.

4. Specifications

The specifications of GC20Mi are shown in **Table 1**.

Table 1 Main specifications

Item		Unit	GC20Mi-35	GC20Mi-63
Distance between centers		mm	350	630
Swing over table		mm	ϕ320	
Center height		mm	1 120	
Grinding diameter		mm	ϕ10～ϕ300	
CBN wheel	Outside diameter	mm	ϕ350 [ϕ100, ϕ150]	
	Max. diameter	mm	20	
	Surface speed	m/s	Wheel diameter ϕ350 – Belt drive specification: 120 [80] [Wheel diameter ϕ350 – DD wheel spindle specification: 160 & 120]	
			[Wheel diameter ϕ100 : 60]	
			[Wheel diameter ϕ150 : 80]	
Wheel spindle	Bearing system	–	Static pressure bearing	
	Drive system	–	Belt drive ϕ350 [ϕ100, ϕ150]	
			[DD drive (ϕ350)]	
Wheelhead feed	Feed system	–	Static pressure square slide, linear motor	
	Rapid feed rate	m/min	ϕ40	
	Min. input increment	mm	ϕ0.0001	
Wheelhead traverse feed	Feed system		V-flat slide, ball screw	
	Rapid feed rate	m/min	20	
	Min. input increment	mm	0.0001	
Workhead	Type	–	Live spindle	
	Center	—	MT No. 4	
	Max. rotation speed	min^{-1}	250	
	Min. input increment	Degree	0.0001	
Footstock	Type	–	Hydraulic type [NC center adjustment type]	
	Center	–	MT No. 4	
	Stroke	mm	Hydraulic stroke 60 [NC stroke 190]	
Motor	Wheel spindle	kW	22 [30]	
	Wheelhead feed	kW	9.8	
	Wheelhead traverse feed	kW	2.9	
	Spindle	kW	2.5	
	Truing unit	kW	0.75 (2P)	
	Wheel spindle pump	kW	3.7 (4P)	
	Hydraulic oil pump	kW	0.75 (4P)	
	Lubricant pump	kW	0.4 (4P)	
Power supply voltage		V	200	
Tank capacity	Bearing oil	L	70	
	Hydraulic oil	L	25	
	Lubrication oil	L	40	
Net mass		kg	11 000	

5. Machine layout

The standard layout of this machine is shown in **Fig. 7**.

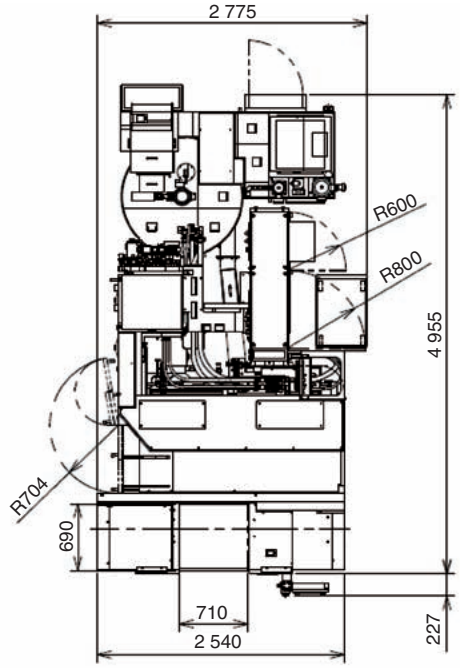

Fig. 7 Machine layout drawing

6. Conclusion

We have developed this GC20Mi with consideration to stable high accuracy, high productivity, improved operability, safety, and the environment. As new technologies and needs continue to emerge, we will embrace them and endeavor to develop equipment that pleases customers.

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