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A Study on the Performance of Cermet Reamer for Transmission Parts

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트랜스미션 부품 전용 가공 Cermet Reamer의 성능 평가에 관한 연구

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ABSTRACT

In this study, Cermet Reamers for planet carrier was manufactured and the machining characteristics were analyzed through processing experiment. Cermet reamer with ∅14, ∅15, ∅18, and ∅21mm was used and machining characteristics were compared and analyzed by observing tool wear, machining hole dimensions and surface roughness. In the flank wear of the tool, the result is less than 0.2mm, which is the target value for each tool size. The experimental results of the machining hole dimensions show the results of the process control range of 3/100 or less according to the size of the tool. Also, the surface roughness measurement result showed a value of less than 0.5 μm in the process control range for each tool size. As a result of observing the experimental results of each ∅, the results satisfied the process standard in both the tool wear, the machining hole dimension and the surface roughness.

Key Words : Cermet Reamer(써멧리머), Automobile Transmission(자동변속기), Carrier(캐리어)

1. Introduction

In planetary gear devices, the planet carrier is a critical part that is assembled from various gears and parts through holes machined in the planet carrier to enable smooth operation[1-2].

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Modern automotive parts are produced from lightweight hard materials. Hence, in the metal-cutting field, there is a continual need for optimal tool geometry design and material development to improve processing precision and productivity. Automotive transmission parts are produced through casting and die-casting processes with cast iron and aluminum alloy, which are known to be difficult to cut. Furthermore, planet carriers produced with hard-to-cut materials require high precision due to the product's nature. The cycle time

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and cutting tool cost due to the multiple processes greatly affect costs and productivity. The holes machined in the planet carrier play the role of facilitating assembly with various gears, smooth driving, and oil discharge. These holes must be machined to create a sophisticated shape for assembly and the smooth operation of parts, and surface machining and removal of burrs are both considered critical in hole machining.[3-5]

In this study, cermet reamer, which is a special tool for a planet carrier, is developed for precise hole machining of planetary gears and the machining characteristics of the planet carrier are analyzed for hole machining.

2. Experimental Setup and Method

Fig. 1 Experimental equipment

Table 1 Experimental equipment specification

Description		Unit	ACE-VM410
Maximum Tracel Distance	X	mm	820
	Y	mm	410
	Z	mm	510
ATC	Type	MAS	BT40
Spindle	Rotation Speed	rpm	12,000
Feed Rate	Rapid Traverse Speed	m/min	30/30/24
	Cutting Feedrate	mm/min	16,000

Fig. 2 Experimental tool

2.1 Experimental Equipment and Tool

A vertical machining center (Doosan ACE-VM410) was used as the experimental equipment in this study. Fig. 1 shows the experimental equipment and Table 1 lists the experimental equipment's specifications. The tool used in this experiment is a proprietary tool that was fabricated by brazing cement on a hard metal body to process the planet carrier. Fig. 2 shows the fabricated experimental tool.

2.2 Planet Carrier

The planet carrier is an experimental workpiece with a double-hole structure that is divided into thermal treatment and non-thermal treatment parts. The holes in the workpiece must be machined such that the assembled planetary gear devices can operate smoothly; burr removal and the inner surface roughness of each hole are important factors. Fig. 3 shows the carrier that is used as the workpiece.

Fig. 3 Experimental workpiece

2.3 Experiment Method

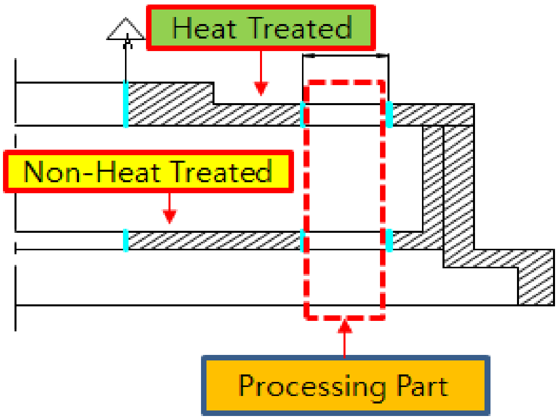

Fig. 4 Experimental method

Table 2 Experimental condition

Tool Size(mm)	∅14, 15, 18, 21		
Processing environment	mist		
Condition	3,000 rpm	Feed Rate 300 (mm/min)	v100 (m/min)
Tool Path	130		

The planet carrier was machined with a cermet reamer that was specifically produced for the carrier. The experiment was conducted to process dual holes of heat-treated and non-heat-treated steel. Four sizes of experimental tools were used: Ø14, Ø15, Ø18, and Ø21. After the experiment, the dimensions, tool wear, and surface roughness of the machined hole were measured and analyzed. Fig. 4 shows the experimental method and Table 2 lists the experimental conditions.

2.4 Measuring Instrument

After the experiment, the hole dimensions were measured with an Air Micrometer (EA-100N) of DEVA Co., Ltd., the surface roughness was measured with KOSAKA (SE300), and tool wear was observed using a tool microscope. The measuring instruments are illustrated in Figs. 5 and 6.

Fig. 5 Air micrometer & surface roughness meter

Fig. 6 Tool microscope (Nikon, MM-400)

3. Experimental Results

3.1 Tool Wear

For tool wear, flank wear was measured using a tool microscope and whether the condition of <0.2 mm was satisfied was observed. The tool wears measured at each diameter (Ø) are shown in Figs. 8–11; they all satisfy the standards for diameter (Ø). The magnification of the tool microscope was set to x200. Table 3 lists the results for tool flank wear; it was 0.186 mm at Ø14, 0.157 mm at Ø16, 0.196 mm at Ø18, and 0.174 mm at Ø21. They were all <0.2 mm.

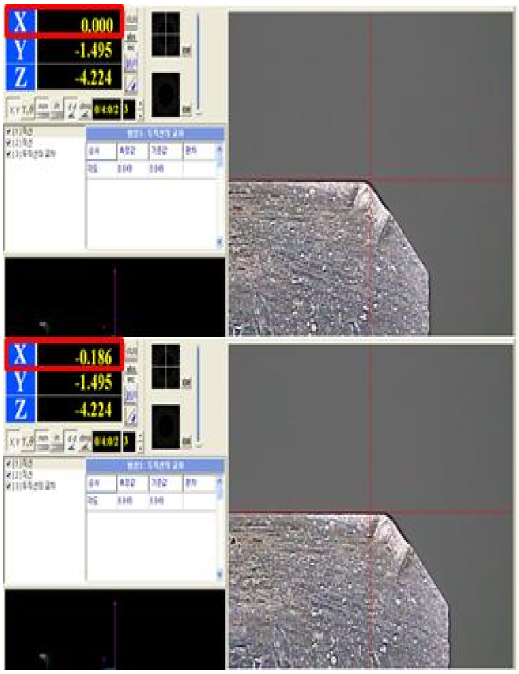

Fig. 7 Result of tool flank wear(∅14mm)

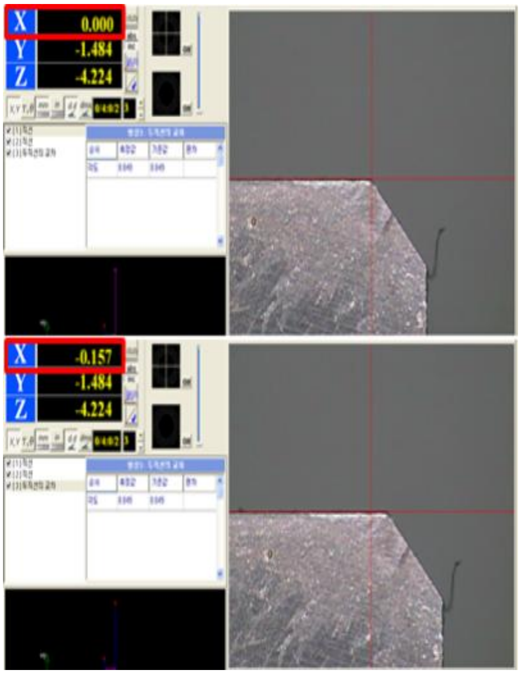

Fig. 8 Result of tool flank wear(∅15mm)

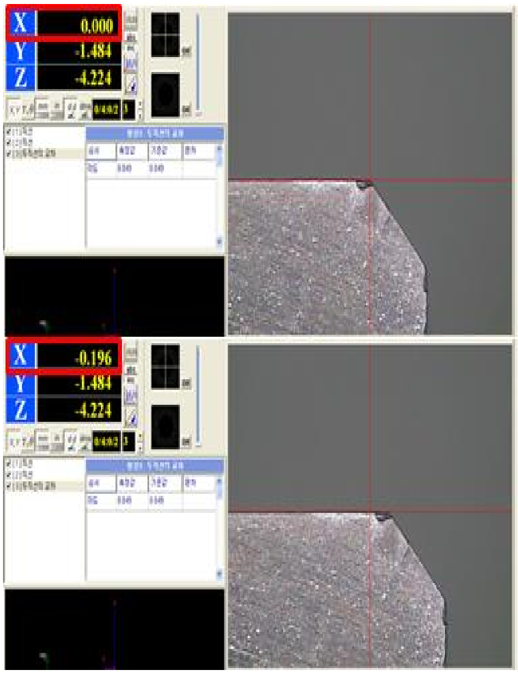

Fig. 9 Result of tool flank wear(∅18mm)

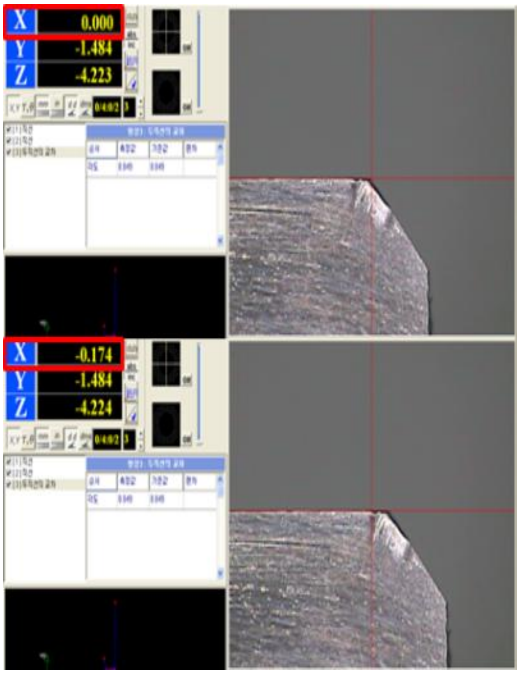

Fig. 10 Result of tool flank wear(∅21mm)

Table 3 Experimental result of tool flank wear

Tool size (mm)	Tool flank wear(mm)
∅14	0.186
∅15	0.157
∅18	0.196
∅21	0.174

Table 4 Experimental result of hole dimensions

Tool size (mm)	∅14	∅15	∅18	∅21
Measuring	14.022 mm	15.023 mm	18.0185 mm	21.021 mm
Dimension range	+0.020~0.023	+0.020~0.023	+0.018~0.021	+0.020~0.023
	≦3/1000	≦3/1000	≦3/1000	≦3/1000

3.2 Dimensions of Machined Holes

The dimensions of the machined holes were measured with an air micrometer and the results satisfied the machining tolerance range for diameter (Ø). It was 14.022 mm for Ø14, 15.023 mm for Ø15, 18.0185 mm for Ø18, and 21.021 mm for Ø21; these values all satisfy the machining tolerance range of 3/1000 managed by the clients. Table 4 lists the standards and results for each diameter (Ø).

3.3 Surface Roughness

The surface roughness was managed under a Ra 0.5 μm based on the client’s standards. After the machining experiment, the surface roughness was measured using a surface roughness measuring instrument. The Ra of the measured surface roughness was 0.137 μm for Ø14, 0.238 μm for Ø15, 0.235 μm for Ø18, and 0.208 μm for Ø21. Thus, they all satisfied the management range of <0.5 μm. Table 5 lists the surface roughness values.

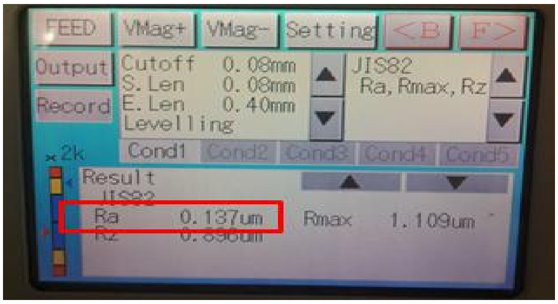

Fig. 11 Result of surface roughness(∅14mm)

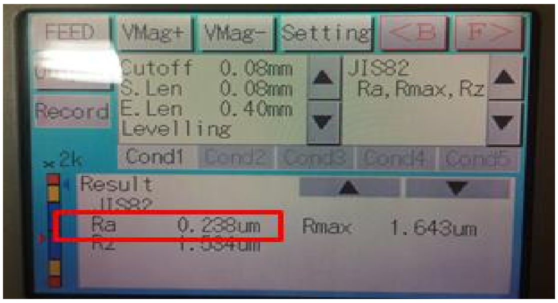

Fig. 12 Result of surface roughness(∅15mm)

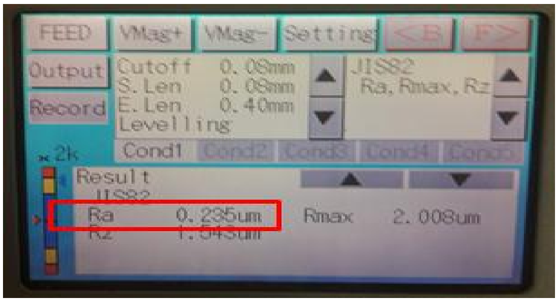

Fig. 13 Result of surface roughness(∅18mm)

Fig. 14 Result of surface roughness(∅21mm)

Table 5 Experimental result of Surface roughness

Tool size (mm)	∅14	∅15	∅18	∅21
Surface roughness	Ra 0.137 (㎛)	Ra 0.238 (㎛)	Ra 0.235 (㎛)	Ra 0.208 (㎛)
Dimension range	≦0.5	≦0.5	≦0.5	≦0.5

4. Conclusions

The machining characteristics of the planet carrier were analyzed with a cermet reamer and the following conclusions were obtained.

1. When tool wear was observed after machining the tool path 130 times, all tools satisfied the flank wear standard of <0.2 mm.
2. All holes in the planet carrier that were machined with a cermet reamer satisfied the managed machining tolerance of 3/1000.
3. The surface roughness results for the machined holes showed the Ra values of 0.137–0.238 μm according to the dimensions; thus, they all satisfied the surface roughness standard of Ra <0.5 μm.
4. The cermet reamer that was specifically produced for transmission machining satisfied all evaluation items and thus could be used as a dedicated tool for a transmission planet carrier.

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