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Development of a Cemented Carbide-Welded Deburring Tool for Burr Removal in Drill Holes of AL6061 Workpieces

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AL6061 소재의 홀 가공 시 버 제거를 위한 초경합금 접합 디버링 공구 개발

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ABSTRACT

In recent years, automated process technology has allowed for the rapid manufacturing of metal parts. Maintaining high product quality is of vital importance during the production of these parts. Surface defects occurring after processing can compromise their assembly precision and performance. In this study, a deburring tool was developed that can remove burrs generated from drilling. Through the evaluation of processing, burrs were completely removed at entrance and exit surfaces. Therefore, this newly developed deburring tool shows better performance than deburring tools currently in use.

Key Words : Drilling(드릴 가공), Burr(버), Deburring(버 제거), Tool(절삭 공구), Surface Quality(표면 품질)

1. Introduction

The burr formed from drilling during cleaner production of parts, if not removed, can be fatal to shape accuracy and surface quality.[1] Thus, removing the burr after drilling with a deburring tool is an essential part of process automation. In the past, burrs formed from processing were manually eliminated using a chisel or a hand deburring tool. Lately, automation equipment such as a machining center possesses an automatic tool changer mode, so the tool in use can be changed to a deburring tool immediately after drilling to remove burrs.[2-4] Burr formation depends on the product's shape, so deburring tools must be customized in manufacturing.[5,6] Many companies in other countries manufacture deburring tools with excellent qualities, while South Korea is still undergoing a research phase. Domestic studies on deburring have covered the processing for a plane, cross-hole, tilted surface, and other special shapes. However, a deburring tool that can remove burr with 100% reliability has not yet been developed. A global manufacturer named "Heule", based in Switzerland, is a company recognized for having over a hundred years-long history of producing deburring tools, leading the global market with original

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deburring tools and technologies. Additionally, they have developed deburring tools with their unique processing principles—these tools are currently available in the market—applied to burr removal depending on a hole shape. In this study, we investigated the processing principles of deburring tools. In our experiments, we applied a deburring tool developed in-house to remove the burr on a workpiece of AL6061 material, widely used for lightweight parts. We examined the burr removal status on the entry and exit parts after deburring, checked to see if any scratches were made on the internal surface of the hole, and confirmed any damages caused by the blade of the deburrer through surface roughness values.

2. Principles of the deburring process

The remaining burr after drilling or reamer processing on the entry and exit surfaces are shown as plastic deformation in Fig. 1. Burr removal is critical in precision parts production. Deburring tools come in various shapes, but there are no significant differences among them when performing the deburring process. Fig. 2 illustrates a schematic of the deburring process. A deburring tool enters the entry part of a workpiece, rotating (Fig. 2(a)); the blade, touching the corner of the entry, performs chamfering (Fig. 2(b)); due to elasticity, the blade gets pushed into the hole along the wall surface and moves rapidly to the exit (Fig. 2(c)). As it leaves the inside of the hole, the blade returns with the restoring force of elasticity. During this process, the curved part on top of the blade is a critical feature; if manufactured with low accuracy, its curved surface may cause a scratch on the internal surface of the hole, negatively affecting the product quality. Thus, leaving the exit surface without damaging the internal surface of a hole is critical, while burr removal is also essential. Processing the exit-side is performed by the back of the blade, following the reverse steps of the entry-side processing. This entire deburring process completes the process of forming one hole. Fig. 3 shows images of the burr formed from drilling a hole on a particular part that was in production. Fig. 3(a) depicts a burr that was ejected from drilling a planar product, while Fig. 3(b) shows the shape of a burr formed in a pipe hole, i.e., a crown burr inside the hole. Fig. 4 presents images of the deburring process in a planar hole and a pipe hole, respectively. Fig. 4(a) shows the results of the deburring process after the drilling of a planar hole, where the burr was removed with consistent chamfer dimensions. Fig. 4 (b) depicts the deburring process for a pipe hole. Burr is still present along the curved surface, showing that the deburring tool did not produce consistent chamfer dimensions. To date, it is not possible to control the chamfer dimensions in a pipe hole using a deburring tool, therefore requiring improvement.

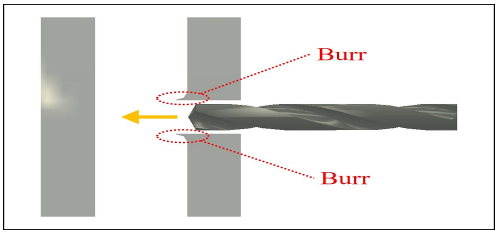


Fig. 1 Burr formation at drilling

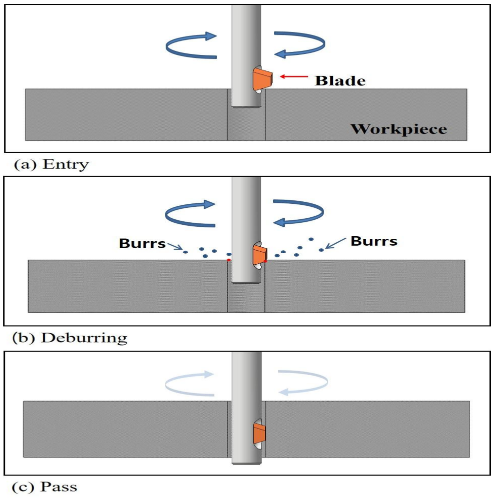
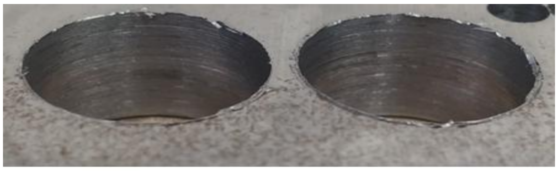


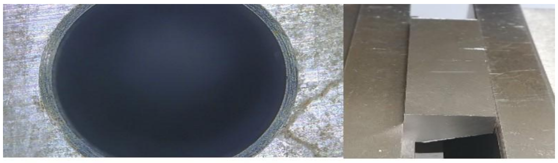
Fig. 2 Schematic diagram of deburring process



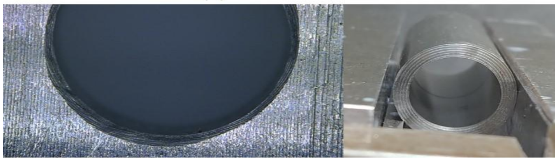
(a) General plane

(b) Curved surface

Fig. 3 Hole images after drilling



(a) Plane hole



(b) Pipe hole

Fig. 4 Hole images after deburring

3. Development and evaluation of the deburring tool

3.1 Designing and manufacturing the deburring tool

Fig. 5 displays a model of the deburring tool that we developed. It is designed to accommodate the removal of a burr at the entry or exit of machined parts. Additionally, it was manufactured with a blade option only for the entry, depending on the hole shape. The blade was manufactured in the form of a point by

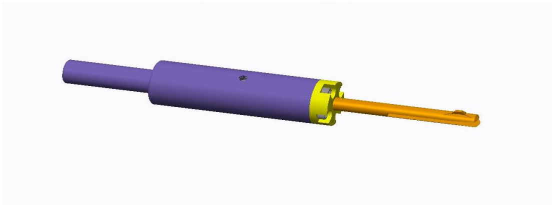


Fig. 5 3D modeling of the deburring tool

Fig. 6 Actual image of the deburring tool

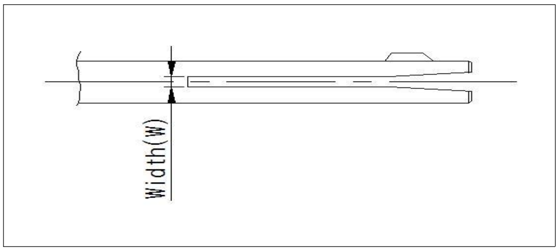


Fig. 7 Concept of wire width(w)

high-frequency welding of a sintered ultra-light alloy (K10). Inside the holder of the deburring tool, a floating part was configured. A compression coil spring was fastened so the blade can be used to process either a tilted surface or a curved shape.

Such characteristic features in our tool resulted in functional improvements by selecting a form with an operating mode different from the blade operating mode of conventionally manufactured products. Regarding the blade shape, our model possesses a reduced tilt, so it receives a reduced load on its entry into a hole. The surface cleared of the burr with the conventional deburring was irregular due to blade vibrations during the process. To solve this problem, we optimized our design through customization, so the blade can move on the body without vibrating. Fig. 6 presents an image of the deburring tool that we developed. The blade can be coated to lengthen the lifespan, or it can be separated from the holder and used as a generic tool. In Fig. 7, the concept of the width of elasticity is illustrated. From experiments, the results of two different widths of elasticities were compared.

3.2 Experiment on deburring process

In this study, experiments were conducted under identical manufacturing conditions to evaluate the performance of the deburring tool that we developed (Table 1). The AL6061 material was used as a workpiece, and a common plate-type material was prepared. A tapping center (DST36D, Daesung Hitech, Korea) was used in our experiment, and the primary specifications used were BT30 and ER collets. Wet processing via refueling water-soluble coolant was used for the experiment. First, the primary manufacturing of a hole was performed by drilling, and then the tool was switched to ATC mode to perform deburring on the same location. Our study results and repeated experiments confirm that the number of rotations and transfer speed were the factors that exerted the most significant influences on the deburring process. These served as a basis for selecting the manufacturing conditions. Additionally, the deburring tool was prepared with width of elasticity values of 1.5 mm and 2.0 mm to evaluate the burr removal dependence on the width of elasticity. The elastic forces of 0.7 kgf and 0.6 kgf were determined to be the active loads, respectively.

3.3 Result and analysis

An experimental deburring process was performed on the entry and exit parts of the AL6061 planar workpiece. Figs. 8–12 show the removal state of a burr and size of chamfer (C), depending on the width of elasticity and processing conditions of the deburring tool. Figs. 9–12 show that the higher the number of rotations at the entry and exit ports, the bigger the chamfer size; the higher the transfer speed, the bigger the chamfer size. Comparing the chamfer size of the entry and exit parts under the F100 processing condition, the chamfer size was significantly greater for the width of elasticity of 2.00 mm than for 1.55 mm. This is likely caused by blade vibrations more significantly affecting the relatively thin body of the deburring tool.

Table 1 Cutting conditions of a deburring tool

	Tools
Workpiece	AL6061
Shape	Flat
Spindle speed(rpm)	500, 750, 1000
Feed rate(mm/min)	100, 200, 300, 400, 500
Tool diameter(∅)	4.9
Drill hole(∅)	5.0

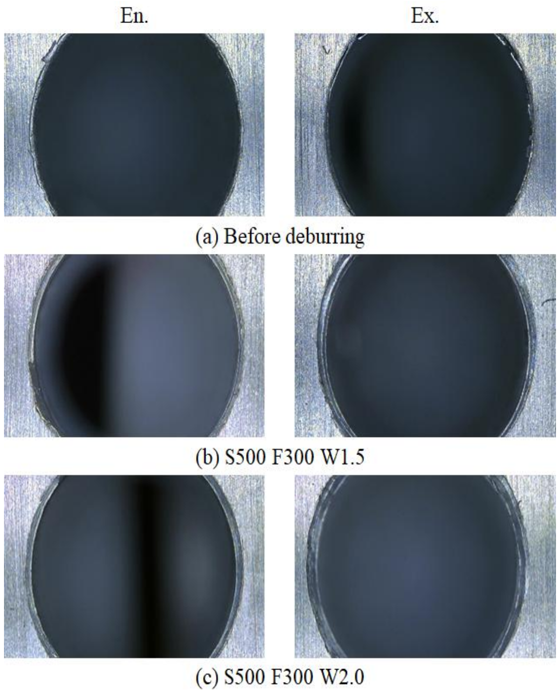


Fig. 8 Results of holes after deburring

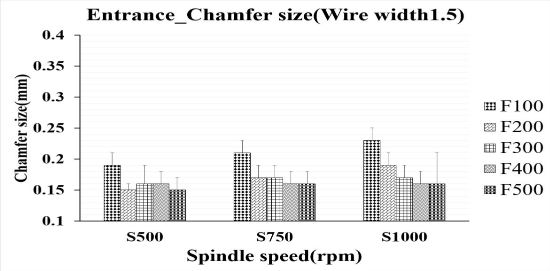


Fig. 9 Chamfer sizes of entrance holes after deburring (W:1.5mm)

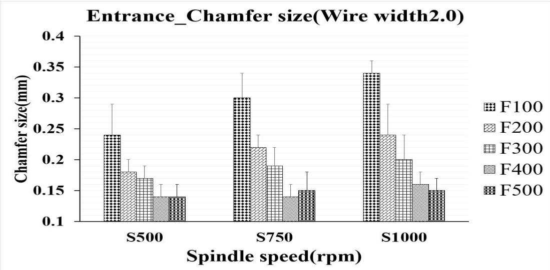


Fig. 10 Chamfer sizes of entrance holes after deburring (W:2.0mm)

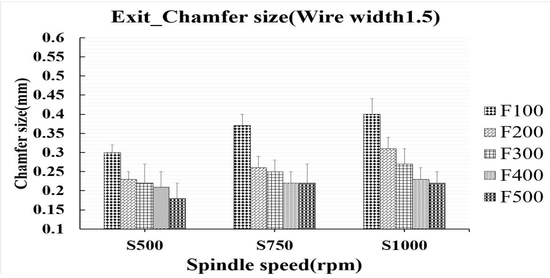


Fig. 11 Chamfer sizes of exit holes after deburring (W:1.5mm)

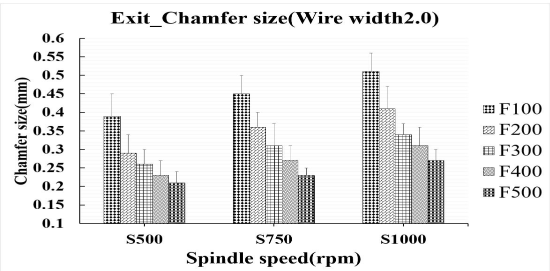


Fig. 12 Chamfer sizes of exit holes after deburring (W:2.0mm)

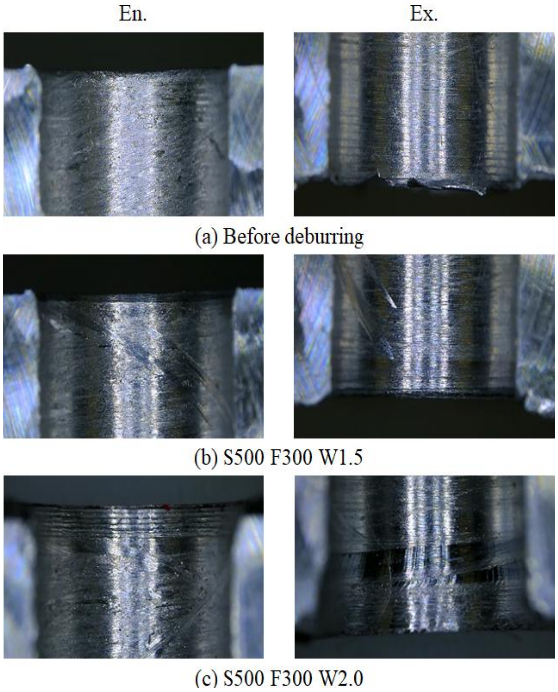


Fig. 13 Hole surface images

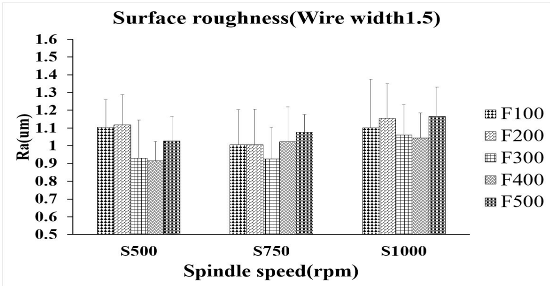


Fig. 14 surface roughness results(W:1.5mm)

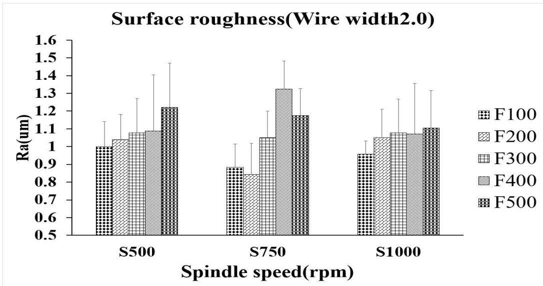


Fig. 15 surface roughness results(W:2.0mm)

Figs. 13(b) and (c) are images showing the inner surface of the hole, displaying a cross-sectional cut of the part after the deburring process. The cross-section of the workpiece was examined after the deburring process, revealing that the movement of the deburring tool inside the hole left a trace. However, the surface quality was confirmed to be similar to the surface condition of the initial hole manufacturing. This indicates that there was no significant damage on the internal surface of a hole caused by the deburring tool.

Figs. 14 and 15 display graphs of surface roughness values according to processing condition and width of elasticity. With the roughness value of basic drilling confirmed at 1.1 ㎛, the average surface roughness value was confirmed to be 0.9–1.1 ㎛ for the width of elasticity of 1.5 mm. Changes in these values with an increasing or decreasing number of rotations or transfer speed were confirmed to be insignificant. In contrast, for the width of elasticity value of 2.0 mm, the average was confirmed to be 0.85–1.3 ㎛. For this value, the surface roughness tended to increase with transfer speed, but the deviation was not significant enough to have a substantial impact, so the surface roughness values were roughly the same. Therefore, we conclude that the surface roughness does not meaningfully increase or decrease as a result of changes in the width of elasticity, the number of rotations, or transfer speed.

4. Conclusion

In this study, we developed a deburring tool for the burr removal process and applied the deburring tool to determine its impact on the quality of the entry and exit parts of a planar AL6061 material, in particular, on the chamfer size and surface roughness. Based on our findings, we drew the following conclusions.

1. The chamfer size from the deburring tool increased as the number of rotations increased and tended to decrease as the transfer speed increased.
2. For our experiments on the chamfer size and width of elasticity, the chamfer size tended to be more significant for the width of elasticity value of 2.0 mm than 1.5 mm.
3. The surface condition and surface roughness values of the machined parts were compared before and after the deburring tool use, and the surface quality was confirmed not to have worsened.
4. In conclusion, the primary purpose of this study of burr removal was achieved, and our findings are expected to contribute to reducing deburring tool processing time by increasing transfer speed during the product manufacturing process.

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REFERENCES

1. Egashira, K., Nomura, Y., Murozaki, Y., and Fukui, J., “Edge finishing and deburring of back surfaces of microholes using micro-cutting tools,” Precision Engineering, Vol. 37, pp. 248-254, 2013.
2. Bae, J. -K., Park, H. -Y., Kwon, B. -C., and Ko, S. -L., “Determination of cutting conditions for an efficient deburring process using a new deburring tool,” Journal of the Korean Society of Manufacturing Process Engineers, Vol. 15, No. 4, pp. 109-117, 2016.
3. Cho, C. -H. and Kim, K. -H., “Design of a deburring tool for intersecting holes in aluminum alloys,” Journal of Materials Processing Technology,

Vol. 212, pp. 1132-1138, 2012.
4. Bae, J. -K., Ahn, D. -H., Kwon, B. -C., and Ko, S. -L., “Development of efficient brush deburring process for valve body of auto transmission,” Journal of the Korean Society of Manufacturing Process Engineers, Vol. 17, No. 1, pp. 144-152, 2018.
5. Lee, K. U. and Ko, S. L., “Developing of deburring tool for the burr at the intersecting holes,” Korean Society for Precision Engineering, pp. 403-404. 2016.
6. Kim, B. K. and Ko, S. L., “Experiment Analysis of the Burr Formation on the Inclined Exit Surface in Drilling,” Journal of the Korean Society for Precision Engineering, Vol. 23, No. 9, pp. 47-53, 2006.