

FEM을 이용한 볼엔드밀 절삭력의 경사면 각도에 따른 분석에 관한 연구

A Study on Analysis about Inclined Surface Angle of Endmill Cutting Force Using FEM

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1. Introduction

In modern manufacturing, because of the reduction of machining time, the improvement of surface roughness and the excellent machining, a difficult stuff such as high-hardness mold, high-speed machining is widely used in an industrial spot.

Ball-end milling has been widely used in cutting molds, dies, turbine blades, impellers and aircraft components with sculptured surfaces. A ball-end mill is essentially composed of a cylindrical part and a hemispheric part formed on the cylindrical tool end. The cutting characteristics such as cutting force, surface roughness and surface profile are varied according to the variation of cutting directions.¹

In this paper, We consider that $\varnothing 30$ ball-endmill's peak point is not included on cutting at inclined plane. Also, the prediction of cutting force according to each of 15°, 30°, 45°, 60° inclined surface toolpath in the ball-end milling process are studied. Using Advantedge production module program, Cutting force in the ball-end milling process can be predicted.

2. Inclined Surface Modeling

The Ball-endmill has character of hemisphere shape. So its stiffness falls in comparison with a facade tool like face cutters. and it does not cut a material theoretically when cutting rate is zero at peak point of the tool.² therefore, we selected the four angles of 15°, 30°, 45° and 60° considering being untouched to tool peak point over 15°. Fig. 1 shows the modeling designed by using CATIA. its cutting area is 50mm×

50mm.

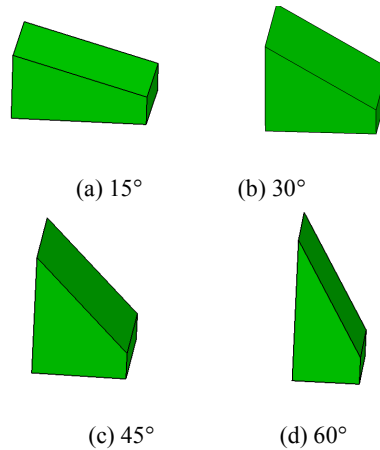


Fig. 1 Modeling of inclined plane

3. Generation of toolpath

Toolpaths were generated by considering 4-direction factor (up-cutting, down-cutting, upward-cutting, downward-cutting) like the Fig. 2. The direction is all one, not bi-direction about each 8 direction. we use PowerMill program for toolpath generation. Fig. 2 shows each eight directions.

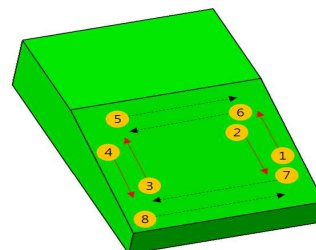


Fig. 2 Cutting directions of inclined plane

There are eight factors determining our cutting directions. They were classified according to up-cutting, down-cutting, upward-cutting, down ward-cutting . They were showed at Table 1.

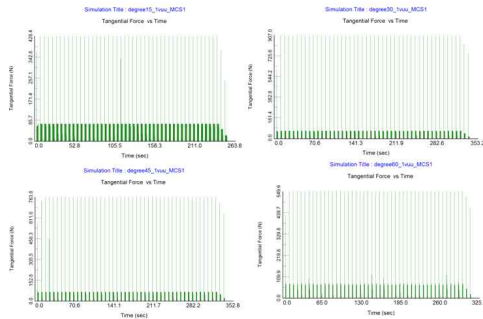
Table 1 Distribution of cutting direction

	Vertical		Horizontal	
	up-ward	down-ward	up-ward	down-ward
up-cutting	1	4	8	5
down-cutting	3	2	7	6

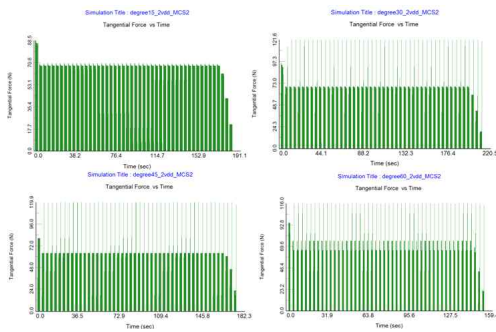
VUU (1) : Vertical, up-cutting, up-ward
 VDD (2) : Vertical, down-cutting, down-ward

:
 (Omit)

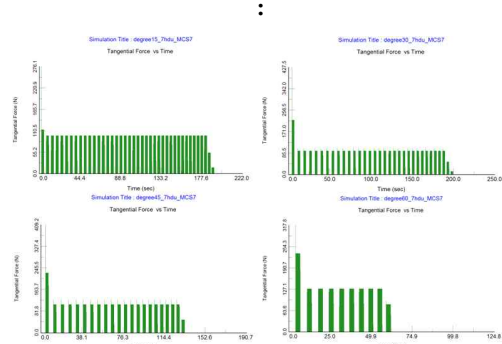
We generated thirty two toolpaths according to both four angles and eight toolpaths. We analysis the graph results of Instantaneous tangential force using the Advantedge production module about the graphs assorted to four angles over same direction. Fig. 3 is graphs gathering the same cutting direction sorted of each angle.



(a) No.1 VUU 15°, 30°, 45°, 60° results



(b) No.2 VDD 15°, 30°, 45°, 60° results



(c) No.7 HDU 15°, 30°, 45°, 60° results
 Fig. 3 results gathering the same cutting direction

4. Conclusions

1. We know that on the ball-endmill cuttings, 30° vertical direction cutting forces were higher than the other cutting at cutting surface entry and the forces in cutting after entry were almost similar to all the vertical cuttings regardless of angles.
2. In the horizontal direction cutting force results, as the inclined surface angle rises, the cutting forces rise. Also, we know the rising trend of instantaneous cutting force not to be shown in result of 15° occurs in cutting force results of 30°, 45°, 60°.
3. On the steep inclined surfaces over 60°, the wear of tool is smaller in the vertical direction raster cutting than the contour cutting, because the vertical cutting force is lower than horizontal.

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References

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