Study of "Sandwiching" state of precision scissors for hair-cutting or medical use

T. Iimura[1], T. Iyama[2], K. Inoue[3]
[1] *Iwate Industrial Research Institute, Japan*
[2] *Iwate University, Japan*
[3] *Tokosha CO., LTD, Japan*

t-iimu@pref.iwate.jp

Abstract

The distinctive structure of precision scissors causes lower vertical direction rigidity in closing motion. As a result, when a load necessary to cut a workpiece by impressing it is heavy, the "Sandwiching" state occurs. The "Sandwiching" state is the state that a workpiece jams into an opened space between two blades of precision scissors, and the precision scissors cannot cut the workpiece. In this paper, we analysed the mechanism of the "Sandwiching" state and present the effects of the vertical load of the blades on the "Sandwiching" state. The result shows that the "Sandwiching" state can be controlled by the vertical load.

1 Introduction

Precision scissors for hair cutting or medical use, which consist of two blades, a screw and some washers, are very important tools for fine cutting. The precision scissors usually have different structures from conventional scissors for cloth or paper cutting to lower the cutting load. A high-precision and complexly curved blade shape, an "Ogami" shape, is necessary for reliable cutting, and a deformability of plastic washer is necessary to smoothen the closing motion of precision scissors. However, the distinctive structure of precision scissors causes lower vertical direction rigidity in cutting motion. As a result, when an impressing load to push and to deform the workpiece with blades is heavy, the "Sandwiching" state occurs. The "Sandwiching" state is the state that the workpiece jams into an opened space between two blades of scissors, and the scissors cannot cut the workpiece. Figure 1 shows a scissors of "Sandwiching" state. In case of hair cutting, the "Sandwiching" causes damaged hairs and discomforts of customers, and in case of medical use, it causes damaged tissues which require a long time to heal. Therefore, it is very important to design a precision scissors for fine and reliable cutting without "Sandwiching".

In this paper, we analysed the mechanism of the "Sandwiching" state and present the effects of the vertical load of blade on the "Sandwiching" state to design the precision scissors for fine and reliable cutting without "Sandwiching".

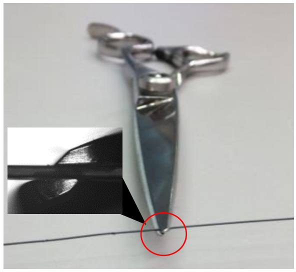


Figure 1: "Sandwiching" state

2 Outline and Movement of Precision Scissors

The following variables are shown in Figure 2; x_1, distance from the blade tip to the crossing point of the blades; $f_i(x_1)$, impressing load at point x_1; $f_v(x_1)$, vertical load at point x_1 ; and γ ,edge angle.

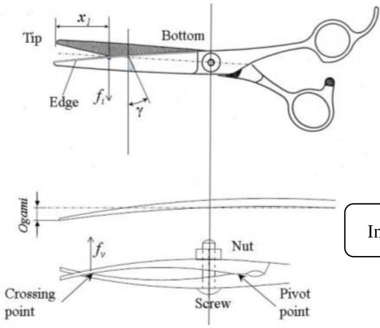


Figure 2: Symbols

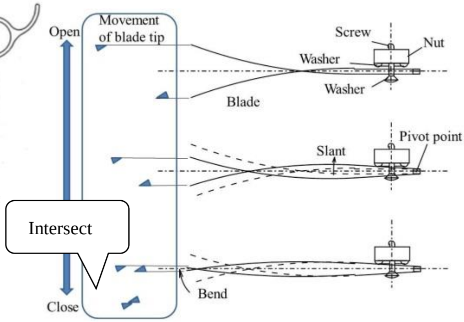


Figure 3: Deformation of blade in closing motion

Figure 3 shows the movement of blades observed from the front and side directions in closing motion. As the blade of precision scissors has "Ogami" shape, the crossing point of blades moves from bottom to tip of the blades in closing motion and the blades intersect each other.

3 Analysis of "Sandwiching" State

Figure 4 shows the relation between the movement of the blades and two loads (impressing load f_i and vertical load f_v) acting upon the blades.

(1) When the impressing load f_i is light, the cutting process is "(a)→(b)→(c)→cut". (a) is the state of just before cutting. (b) is the state that the blade starts to impress the workpiece, and f_i and f_v act upon the blades,where f_i is changed by the radius of edge and hardness of the workpiece, and f_v is changed by the specifications of the blades (e.g. "Ogami" shape or tightness of screw). In this process, $f_i \cos(\gamma/2)$ acts upon the both surfaces of the blade edge (Figure 4 (b')) and the workpiece is leaned $\gamma/2$. So the workpiece and the center line of the blade cross at right angle. (c) is the state that the cutting proceeds smoothly, because the load required to cut (f_i) is light and defomation of workpiece is little. Therefore the angle of workpiece (β) can be held "$\beta = \gamma/2$".

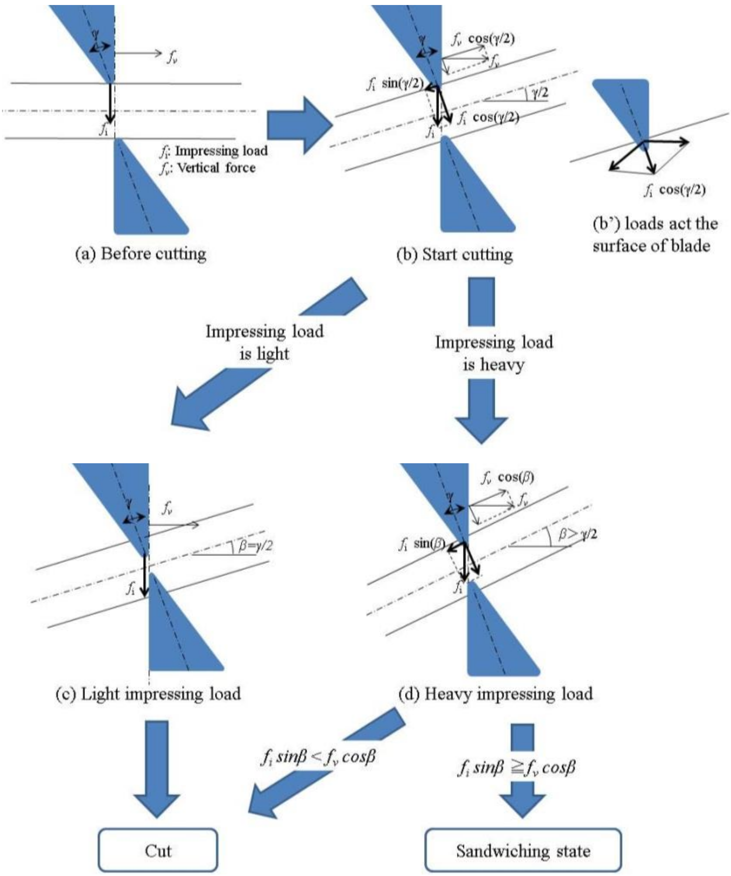
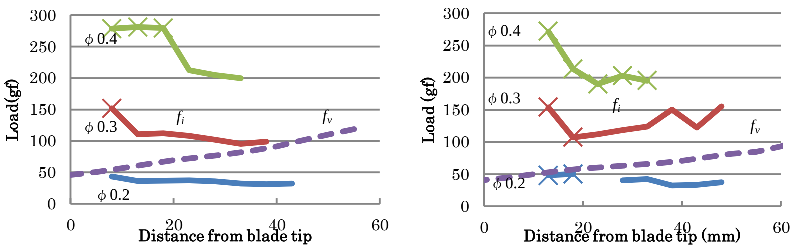


Figure 4: Relation between the movementof blades and loads

(2) When the impressing load f_i is heavy, the cutting process is "(a)→(b)→(d)→cut" or "(a)→(b)→(d)→the "Sandwiching" state". (a) and (b) are the same processes when f_i is light. (d) is the state that the blade edge deforms the workpiece, and the workpiece is leaned β, where β is larger than $\gamma/2$. In this case, if "$f_i\ sin\beta < f_v\ cos\beta$", then the blades move only closing direction and deforme workpiece, because blades suppress each other to move to f_v direction. As a result, if the condition "$f_i\ sin\beta < f_v\ cos\beta$" is held during the process (d), then the cutting proceeds. On the other hand, if "$f_i\ sin\beta \geqq f_v\ cos\beta$", then blades move vertical direction (a direction oposite to f_v) and the "Sandwiching" state occurs. Therefore the "Sandwiching" state is incident when f_v is light and β is large.



(a) f_v is heavy (b) f_v is light

Figure 5: Comparison among f_i and f_v

To validate the above analysis, the measured f_i (solid lines) and the analysed f_v (bloken lines) in the cases when 3 kinds of nylon strings (ϕ 0.4, 0.3, 0.2mm) are cut with scissors whose radius of edge is R1.3 μ m under the light and heavy vertical loads f_v controlled with the tightness of screw are shown in Figure 5, where "×" mark shows the "Sandwiching" state occurs. From Figure 5, it is presented that the "Sandwiching" state is incident when f_v is light, and the "Sandwiching" state can be controlled by the vertical load f_v.

4 Conclusion

The results show that; (1) When "$f_i\ sin\beta \geqq f_v\ cos\beta$", the "Sandwiching" state occurs. (2) The "Sandwiching" state suppressed by controlling the vertical load f_v (e.g. controlling the tightness of screw).