Special Jury Award

OJIGI TOKURI Self-Tilting Sake Bottle

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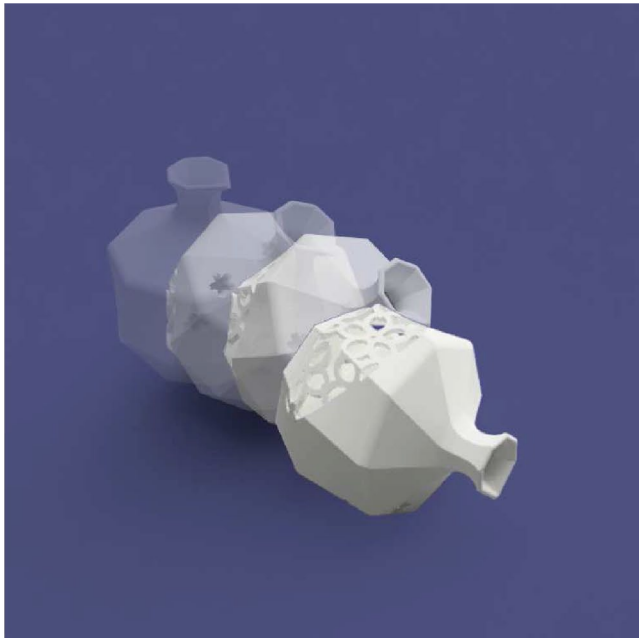
Shoko KAWATA, Kazuki TAKENOUCHI "*OJIGI TOKURI* (Self-Tilting Sake Bottle)" 2017, Material: VeroWhite, Size: 94W x 94D x 86H (mm)

OJIGI TOKURI can tell the remaining quantity of sake inside by changing its tilting position, while remaining sake is invisible in a traditional one made of opaque china. This unique behavior of the tilting is generated by its computationally optimized asymmetrical inner configuration, which changes the center of gravity with a decrease of sake with holding a stable tilting position in 4 steps. Moderate movement to the next stable position is given by double curved surface patches. Elegant openwork and deep extrude cut figured with cherry blossoms implicitly show the mechanism of tilting.

Keywords: Digital modeling, Digital fabrication, Statics, Tokuri, Optimization, Engineering calculation



1 Introduction

In a Japanese traditional style of drinking sake for two, sake is served in a *tokuri*, one of Japanese traditional bottles for sake holding standard content volume of 180ml or 360ml called as 1-*gou toukri* or 2-*gou tokuri*, respectively. As a manner in this case, drinkers are expected to fill sake each other into partner's small sake cup, *sakazuki*, and at every filling sake in the *tokuri* gradually reduces. As such *tokuri* is in general an opaque china, the remaining quantity is estimated by shaking the tokuri or by looking into it, and the empty *tokuri* is often laid down as a sign of drinking up. All these behaviors are however against good manners.

The authors' work *OJIGI TOKURI* at the top of this page helps drinkers and servers see the quantity of sake in the bottle without impolite behaviors by tilting depending on the remaining. The name *OJIGI TOKURI* comes from a Japanese traditional greeting, *ojigi*, making a bow; tilting behavior of *tokuri* is similar to *ojigi* in terms of both moving and having some of degrees as illustrated in the top right figure.

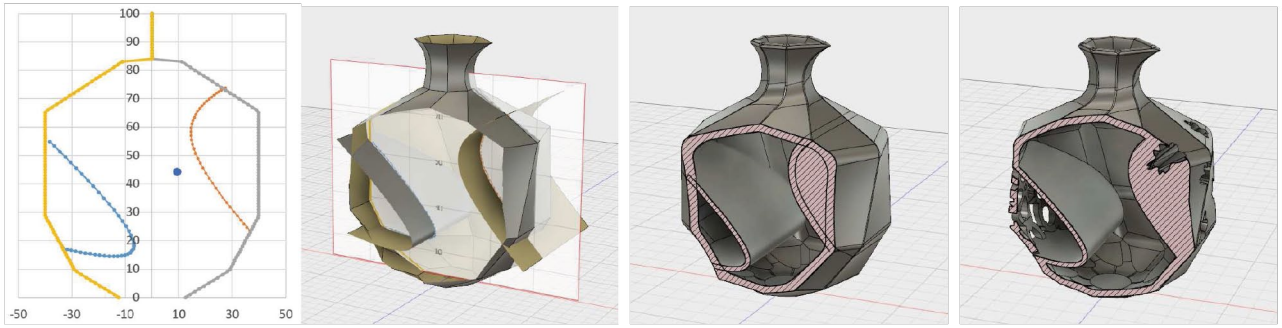
2 Idea and design requirements

Since tilt of *OJIGI TOKURI* is caused by a move of the center of gravity with a decrease of sake in *tokuri*, its asymmetrical inner surface configuration not interfering with

the flow of sake should be carefully determined to satisfy the statics in accordance with the outer contour. In addition to the above requirements, the authors imposed following design requirements to the *tokuri* for a practical use:

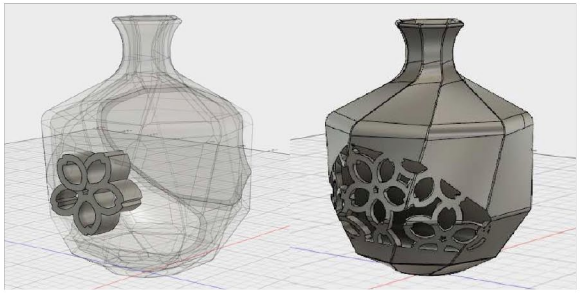
- holding the standard content volume (180ml)
- visualizing a quantity of remaining sake with some tilting degrees and staying stable at rest in a single inclination for each particular quantity of sake
- tilting with moderate motion not to pour out the sake in *tokuri* nor break itself by impact

In order to simultaneously meet these complex requirements, a numerical evaluation is necessary on geometry and statics for a tentatively determined configuration at every tilting position followed by a modification to a better result.



(a) Optimized configuration of cross-section (b) Principal surfaces generated based on sketch (c) Solid body constructed with outer and inner faces (d) Completed model with openwork and lightening

Figure 1: Modeling process of *OJIGI TOKURI*



(a) Basic solid pattern (b) Completed openwork

Figure 2: Openwork by use of Boolean operation

Figure 3: Fabricated prototypes for performance confirmation

3 Modeling environment and procedure

As design of such a novel product is a creative work, successive modification and even introduction of addtional requirements and constraints found out in the process will be required. To handle such process, the configuration of *tokuri*, cross-section of outer and inner surfaces, was evaluated and optimized by use of spreadsheet, not special CAE tools nor a programing languages that require special knowledge and skills to users. Furthermore, as shown in Fig.1(a), the users can confirm calculated results by instantly illustrated outline of the *tokuri* and the position of center of gravity at each tilting position as 2D plots.

Digital 3D modeling of the *tokuri* was carries out on Fusion 360: 2D sketch was drawn by tracing the profiles determined based on calculation on spreadsheet, and 3D surfaces in Fig.1(b) were generated based on the sketch. Its outer and inner surfaces were then joined into a solid body in Fig.1(c). Finally, openwork and lightening in Fig.1(d) were added for better performance of *tokuri*.

The openwork is partly for a better performance by making fine adjustment, and also for disclosing the existence of inner partition, impressing the mechanism of generating its interesting behavior. In the modeling of the openwork, Boolean operation was applied with a basic solid pattern shown in Fig.2(a) and arranged on the shell of hollowed area in Fig.2(b).

4 Final model of *OJIGI TOKURI*

The final model is shown at the top of the first page and in Fig.2(b). The behavior has been improved through the five prototypes fabricated with FDM 3D printer as shown in Fig.3 from the left to the right.

The five prototypes are constructed with an axially symmetrical outer surface or combination of ruled surface; the final model is constructed with small curved surface patches. The patches are generated by connecting regular octagons by use of loft surface, one of the most fundamental functions of 3D CAD, octagons which are storied along *tokuri*'s centerline with a relative revolution between the neighboring two polygons. Such curved surface patches seem to be effective to give *OJIGI TOKURI* a moderate tilting motion to a feasible direction, being expected to avoid *tokuri* rolling off the table and being damaged by the impact. To control its tilting behavior, an appropriate fillet size is chosen for each edge of patches.

The contour of the bottom face is a circle for a smooth start of tilting. Surface cut with a truncated circular cone is applied for the connection between the circular bottom face and the octagonal section.

Also to implicitly show the existence of solid weight opposite to the hollow partition, the other mechanism of the tilting behavior, rather deep extrude cuts having a contour of flower are added.