Squeeze Performance of Oval Containers

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INTRODUCTION

Household cleaning agents and many salad dressings, mayonnaise, ketchup and condiments are often packaged in oval shaped containers that need squeezing action to dispense. These containers are often out in the open in display on a kitchen table or sink and have enough visibility that brand owners still want them to look attractive and functional. In a sense, they should not look distorted or disheveled after a period of use. On the store front they cannot have a dented look which could be due to excessively thin corners or a non-optimal stacking arrangement. Typically, a wide label panel area is preferred for boldly displaying the brand identity and the numerous marketing aspects of the product but it does not necessarily imply the best dispensing or ergonomics [1,3]. On the contrary, most of the time a wide flat paneled container is the most challenging to blow, needing specialized equipment and is most prone to denting and buckling [2]. Having a well-defined grip area and something that does not crumple under the finger indentation force, dispensing controlled amounts of liquid would be a great package leading to good consumer satisfaction [4].

EXECUTIVE SUMMARY

In this study, PTI delved deep to find the many attributes of containers that make them easier or harder to dispense. The force to squeeze has been recorded for a variety of 20oz. -25oz. containers in a number of product segments. It has been commonly reported in the industry that for a container to have good squeeze strength the force of deformation should be correlated to the indentation in a linear fashion early on with a goal of 2.2 lbf of resistance for 0.4 inches of deformation.

OBJECTIVE

In this study, PTI delved deep to find the many attributes of containers that make them easier or harder to dispense. The force needed to dispense along with the amount dispensed per mm of indentation were tracked for different package segments. To make the comparisons fair, same size containers in a similar market segment were analyzed.

PRODUCT CATEGORIES

It was interesting to note that in the 20oz ketchup category almost all of the designs were rectangular or oval shaped containers with a very short flat shoulder compared to the 24oz shape where almost all of them had a long neck. The weights of the 24oz and 20oz ketchup packages ranged between 35g and 41g with a good amount of overlap where the lightest weight 24oz package was lighter than the heaviest weight 20oz package. All of the 20oz ketchup sizes investigated in this study had a large flip top over cap for the inverted standup capability which has been an attribute that saw market introduction in the late nineties as a novel way to have the viscous ketchup ready for dispensing the moment the cap was flipped.
These caps had SP 400 33mm closures which were twice as heavy and wide compared to the 24oz long neck ketchup bottles with the same finish. In comparison, the 23oz-25oz dish soaps all had 28mm SP 400 finish. In the long neck category, the ketchup bottle sizes are in the 24oz segment as shown in Figure 2. The weights for the 24oz size overlap quite a bit with the smaller 20oz size though on an average they are 2-3g heavier.

In the dish soap space the 23-25oz package sizes are interestingly in the same 36-40g range which is also the same for the ketchup bottles although the shape and geometry of these containers are quite significantly different from those of the ketchup containers. This is shown in Figure 3 below.

Material distribution was measured with a Torus equipment at different height and circumferential locations of the different size containers. The entire package weight in terms of bottle, closure and label were measured by separating them to get a clear idea of each constituent of the package. Finally, the package Top Load which is important for filling, stacking and distribution was measured along with the squeeze load using an MTS tensile tester at a speed of 2”/minute.

The weight distribution of the various size containers is shown below in chart 2 and it is evident that the 20oz ketchup bottles with inverted dispensing have a much heavier 33mm closure in the 9-11g range compared to a 24oz long neck or dish soap bottle with a 3-4g closure. The overall material savings are much better for the narrow neck closures. The labels hardly account for 1g in the total package weight, no matter how extensive a surface they are applied over.

The major and minor wall thickness distribution for the 20oz. Ketchup sizes are shown below in Chart 3. As expected the minor axis is significantly thicker compared to the major axis even though a number of these packages with high aspect ratio are probably blow molded using preferential heating which is supposed to even out the difference between major and minor. The shoulder and heel areas of the bottles are thinnest at 0.4-0.6mm both along the major

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**PROCEDURE**

The following sets of data were collected from the various bottle samples:

- Material Thickness Distribution
- Weight distribution in package, closure and label
- Empty and Filled Top Load & Squeeze Load

**RESULTS & DISCUSSION**

The empty vented Top Load results for the ketchup and dish soap categories are shown below in Chart 1 and they are in the 40 to 80 lbf range with one outlier at 140 lbf. However that can be perhaps explained as a result of its outlier weight being 10-15g heavier as shown in Chart 2. Excluding that data set, the Top Load was highest for the long neck Meijer 24oz. ketchup bottle with the Kroger bottle a close second. This does indicate that the long neck 24oz. ketchup bottles with similar to 20oz. weight target and higher volume capacity has better top load compared to their flat neck counterparts. This is also intuitive from a structural perspective as a sharper shoulder would be less capable of supporting a vertical load. A higher thickness distribution would be necessary for such short neck containers to have a higher top load.
and minor profiles while the grip area is the thickest at close to 0.5-0.8mm.

Across different product categories, it is interesting to note that this label area where most of the package handling and dispensing interactions take place have a thickness distribution in the 0.4mm-0.6mm range. This is shown in Chart 4.

The squeeze load testing done by indenting the center of the label panel area with a rounded probe at 2”/minute. The results shown in chart 5 below indicate that there is quite a spread ranging from 1.5 lbf to 5.5 lbf with the majority of the containers in the 3 lbf range. Three of the sizes have squeeze resistance greater than 4 lbf and these containers are also in the higher weight bracket in their respective categories. The French’s 20oz ketchup bottle is 37.4g while the Organic Ville 20oz ketchup is 40.3g and Annie’s 24oz ketchup is also 37.4g. Interestingly, these containers don’t necessarily have the highest top load and the Annie’s ketchup bottle has only 27 lbf top load strength suggesting what works for top load does not necessarily translate into squeeze load. Even the highest weight 50.2g JR Watkins bottle has a sub 4 lbf squeeze strength but a top load strength exceeding 140 lbf. As stated earlier, the de facto industry standard is to strive for at least 2.2 lbf of deformation at 0.4” side indentation and the data suggests that barring 4 different sets, most of the tested containers seemed to be fulfilling this requirement.

Conclusions & Next Steps

This study shows that most of these containers in the same size range with widely differing geometry have similar weights barring a few outliers like the JR Watkins bottle. However, there is a great interplay between container grip region geometry, thickness distribution and squeeze performance. There most possibly exists an optimal cross section and thickness distribution for each geometry envelope that can maximize the performance of both top load and squeeze load. Further there is possibility of light weighting the container by changing shoulder angle, container aspect ratio and grip geometry. This is evident from how the long neck containers of higher volume and similar weight have higher top load strength. Computer simulations can today drive each of these performance criteria to an optimized value using iterations in the virtual design engineering space. There is a great potential to determine apriori other critical parameters that drive consumer satisfaction like ergonomics, easy pouring and bottle stability. These would be addressed in future studies.

References


Figure 1. 20oz ketchup bottles with flip top inverted SP 400 33mm closures

Figure 2. Long Neck ketchup containers in the 24oz. category with SP 400 28mm closures
Figure 3. Dish soap bottles win the 24-25oz category with 28mm SP 400 finish
Chart 1. Empty Vented Top Load
Chart 2. Package Weight distribution

Chart 3. Material Distribution
Chart 4. Label Thickness Distribution

1. Kroger 20oz Ketchup
2. Heinz 20oz Ketchup
3. Hunt’s 20oz Ketchup
4. French’s 20oz Ketchup
5. Great Value 20oz Ketchup
6. Palmolive 25oz Dish Soap
7. Kroger 24oz Dish Soap
8. Check This Out… 25oz Dish Soap
9. Finish 23oz Dish Soap
10. Gain 24oz Dish Soap
11. Great Value 24oz Dish Soap
12. Meijer 24oz Dish Soap
13. Vista 25oz Dish Soap
14. JR Watkins 24oz Dish Soap
15. Kroger 24oz Ketchup
16. Hunt’s 24oz Ketchup
17. Organic Ville 24oz Ketchup
18. Meijer 24oz Ketchup
19. Annie’s 24oz Ketchup

Chart 5. Squeeze Load Performance