Ketchup Bottle Lid and Accessories Design Report

Introduction:
Our design brief requested a solution to the issue of dried ketchup accumulation on ketchup bottle caps belonging to 1.5 litre ketchup bottles which contribute to a displeasing aesthetic, an increase in the difficulty in applying the sauce due to clogging in the nozzle, and the uncleanliness of the cap. This problem could be attributed to holding the bottle too close to the food substance that the ketchup sauce is being applied to, closing the lid while ketchup sauce still remains on top of the cap, applying ketchup at a steep angle resulting in it flopping onto the lid, or simple carelessness while handling the bottle among other things. The task was to either redesign the bottle cap or design an accessory for the ketchup bottle to reduce sauce accumulation and make the process of ejecting the sauce from the bottle more controlled and precise. Design for usability and effectiveness were ranked above other DFX's.

Despite being a relevant problem, the difficulty of the design process was that Heinz had already made multiple attempts to address the problem in the past by redesigning the cap. Heinz’s engineers increased the diameter and made the cap surface flatter to support an inverted bottle design, added a silicone valve closure as well as water reservoirs to minimize leaking and watery discharge while improving the ‘suck-back’ function of the cap to pull ketchup back into the bottle, and made the opening 0.1 inches wide to increase directional control. Also the brief was unclear in laying out the objectives because it did not specify whether all the objectives were independent of each other or whether one objective was a high-level objective and the other objectives could be classified as detailed objectives that could be grouped under said high-level objective. For example, ridding the lid of ketchup residue could have been seen as a high-level objective that encompassed objectives such as improving the precision of sauce ejection and minimizing sauce waste. In our high-level concepts, we assumed that by focusing on minimizing ketchup residue, the remainder of the objectives listed in the brief would be addressed indirectly.

Asides from minor changes like adding metrics to constraints, moving entries under the constraints, objectives and criteria headings to different headings where they fit better, the revised brief was kept in line with the clients’ original problem brief with consumer centric framing. Also since Heinz offers ketchup bottles in metric units in Canada and the largest model ketchup that they offer in Canada is 1.5L, the brief was revised to target 1.5L models of Heinz Ketchup bottles rather that 6 4oz models.

The solution was designed with the following constraints:

- Must not change the amount of ketchup in the bottle
- Must not introduce problems with ketchup mixture separation within the bottle
- Must not shorten the shelf life of the ketchup bottle sauce – 15 months
- Must not require a change to the make-up of the sauce
- Must use materials that meet the safety requirements in Section B.23.001 of the Food and Drugs Act and Regulations
- Must be able to withstand the temperature ranges from 0 to 60 degree Celsius.
- Must be recyclable or reusable

The designs were then assessed with the following criteria:

- Usability; (lesser extent to which the user has to deviate from their usual interactions with the Heinz ketchup bottle)
- Cleanliness; (smaller volumes of ketchup sauce left on the lid and in the nozzle)
• Precision; (more constant flow rate of the ketchup sauce)
• Affordability; (smaller ratio of amount spent by the user on the design to number of ketchup bottles the design can be used for)
• Durability; (greater force the design can withstand before becoming dysfunctional)
• Force needed to eject sauce; (smaller ratio of the force applied by the user to the volume of ketchup ejected by the bottle)
• Accessibility; (greater percentage of people that the design is accessible to)

The Iterative Process:
We began the iterative process of coming up with divergent solutions by using the creativity technique, reverse brainstorming. This technique consisted of identifying the problem, identifying the causes of the problem, designing solutions that would create said causes, and then reversing the reverse problem solutions to create solutions to the original problem. In this brief, we defined the problem as ‘finding a way to minimize ketchup accumulation on the ketchup bottle lid and in the ketchup bottle nozzle’.

The following were causes of the problem we identified:
• Holding the bottle too close to food when you squirt the ketchup
• Closing the lid when there is still ketchup on top of the lid
• Squeezing the ketchup bottle really hard and in quick spurts, which increases the likeliness of ketchup splashing back up onto the lid
• Holding the bottle at an insufficiently steep angle which causes ketchup to spill or flow onto the lid
• Accumulation of ketchup in nozzle as a by-product of everyday use of the ketchup bottle
• Having to shake the bottle because ketchup is stuck at the bottom...

We then reversed the above solutions and grouped...

We then reversed the above solutions and sorted them according to the specific aspect of the problem they were trying to address and the method they were using to address said aspect of the problem. We found that solutions could be divided into two categories: remedial and preventative. Remedial solutions...
attempt to minimize the effort that the user has to expend to remove any ketchup residue that has already accumulated in the nozzle or on the cap. Preventative solutions attempt to prevent ketchup residue from accumulating in the nozzle or on the cap in the first place. Finally we deployed the converging creative technique, hundred euro test. This technique consisted of allocating each group member an imaginary amount of money - in this case € 100 - and having each group member invest in each concept with the mindset that they were going to receive profit based on how much they invested and how much success each idea would have. After which, we totalled the amount of money each idea received and eliminated or combined weaker ideas based on the amount of money they received to create our candidate concepts.

The following are the solution grouping we created with the total euros that were allocated to them besides them:

Preventative:

1. Implement a slightly elongated nozzle (€115)
2. Implement a vent-like mechanism that eliminates air bubbles (€70)
3. Implement a support system that alleviates the load of the ketchup bottle from the user (€60)
4. Implement warning label stickers that warn against practices that may cause ketchup accumulation on the cap (€15)

Remedial:

1. Implement one-sided adhesive papers that attach to the cap that protect the surface and are easily disposable (€50)
2. Implement a cleaning utility that makes the process of cleaning the lid easier (€105)

The next sections covers the final candidate concepts.

Candidate Concepts:

Preventative Solution (Pointed Lid):

This concept solution implements the design of a new cap. This cap should have a pointed nozzle that extends outwards from the base of the cap for higher precision. A flat lid that covers the nozzle entirely should also be implemented so that there is a flat surface for the bottle to stand upside down on. A valve that prevents ketchup from just falling out of the lid should be places at the base of the nozzle so that for ketchup to enter the triangular part of the nozzle it must first pass through the valve. Because the valve is not at the tip of the nozzle where the diameter is smaller, it is less likely for ketchup to get clogged up right at the tip. Also the inside of the nozzle should be as frictionless a surface as possible so as to prevent ketchup from getting caught in the nozzle and drying up to clog it.

The nozzle extending out from the base of the cap allows for the user to hold the entire ketchup bottle farther away from where they want to apply the ketchup. This reduces the chance that ketchup will get smeared around the base of the nozzle and the cap thereby increasing the cleanliness of the cap as a whole.

However, the increased size of the lid also increases the cost of producing this new design as more plastic would have to be used. Also, when the bottle is stored upside down, the centre of gravity of the bottle will be higher up and the bottle will be less stable.
Preventative Solution (Cap Vent System):

This concept solution is the implementation of a lid with a vent. After the bottle is squeezed and released, the vent takes in air using a straw, directing the air bubbles away from the lid. One reason for ketchup accumulating around the lid of the bottle is the scattering of ketchup caused by the ejection of a ketchup-and-air mixture. In response to this, this solution looks to prevent air bubbles getting into the bottle nozzle when the bottle is released after being squeezed. The lid has an air vent that lets in air through a straw to the bottom of the bottle when it is upside down after pressure on the bottle is released. The vent will have a concave rubber seal so that it only allows air in one way and ketchup cannot fall into the straw and escape through this second hole. Similarly, the ketchup ejection hole will be guarded by a similar one way valve so that ketchup can only come out and air cannot be sucked back in through this hole. As a result of these one way valves, the air will go up the straw instead of the ketchup ejection hole. Additionally, there is less force from the ketchup pushing down on the opening of the straw inside the bottle compared to the ketchup ejection hole because the opening of the straw is higher up and there is a lower volume of ketchup above it, which would mean that the ketchup would eject from the correct hole before ejecting through the air vent.

This solution is user friendly because it doesn’t require the user to deviate from their usual interactions with Heinz ketchup bottles. Furthermore, it prevents the formation of air bubbles as a result of releasing the pressure on the bottle after squeezing out ketchup and sucking air in the ejection hole. As a result, the likelihood of ketchup exploding out of the lid because there was an air bubble blocking it is minimized and ketchup ejection is thereby simplified.

Since this cap will be used as part of a food container, the choice of material of the cap is important, especially in terms of safety. As well, cost is also important since the cost of a cap from a ketchup bottle cannot be too high. Therefore, a safe plastic material is recommended. In terms of raw materials, there is only the addition of a plastic straw, and so by using plastic, this solution would be low cost. As shown in the drawing, the structure of this design is very similar to the reference design, with the only change of addition of the straw. Thus, it should have the similar durability and accessibility with great improve in functionality.

Preventative Solution (Ketchup Bottle Stand):

This concept introduces a rigid support system for the ketchup bottle that aids the user in steadying the bottle. This bottle stand will allow users to focus their energy on aiming the ketchup bottle at the food, thereby minimizing the chance that ketchup will be smeared on the lid, which occurs when the bottle accidentally comes in contact with the food or when ketchup splashes back onto the ketchup bottle lid.

The 1.5L ketchup bottle that the brief targets was measured to have a circumference of approximately 31 cm and the average adult male hand length is 20 cm. Since the average adult male hand length is more than half the circumference of the bottle, they should be able to grip it, but for women, who have an average hand length of 18 cm, and children with even smaller hands, they may not be able to get as good a grip on the bottle in order to both support and aim it onto the food they might be holding in their other hand. Because this stand supports the bottle, it eliminates the need to grip it and hold it steady so people with small hands can accurately apply ketchup to their
food too. This design also contributes to the accessibility of ketchup bottles by allowing elderly and children who are known for having a weaker grip strength to squeeze the bottle with both hands.

In terms of usability, the manner by which the user is meant to use the product should be intuitive. The overall aesthetic should be suggestive of how and where the bottle is meant to be positioned and the structure should not interfere with attempts to squeeze the bottle or to aim the bottle nozzle. In terms of effectiveness, the ketchup bottle stand satisfies its purpose. It virtually eliminates any load that the user has to carry and provides a rigid support from which the user can precisely apply the ketchup sauce. Not only that but, since the bottle is being held upside down, the stand also eliminates the need to smack and shake the bottle to get ketchup to the nozzle because gravity will have it there already.

The overall cost of the design would come from the cost of the material used and the cost of manufacturing the stand. The cost of manufacturing would not be high since there are no complex parts to be assembled. Although, plastic seems like an obvious choice of material because it is a low cost option, something stronger and more resistant to temperature change should be used to construct the stand in order for the stand to be durable and able to support the heavy bottle.

**Remedial Solution (Quick Cleaner Stickers):**

This concept solution solves the problem of dried ketchup residue on the body of the cap as well as under the lid, which decreases cleanliness by making the lid sticky and harder to close. This solution is a pad of one-sided adhesive papers in the shape of the lid but scaled slightly smaller in order to fit inside the walls of the lid when the lid is closed. They will also have a hole in them to accommodate for the nozzle. The stickers will have adhesive on one side to stick to the other stickers under them and are made of material able to hold the ketchup that sticks to the stickers. As this concept requires little change from the user in terms of their usual interactions with ketchup bottles, the ease of use is not affected significantly. The user will only have to stick the stack of stickers on the body of the cap and the bottom of the lid once. Once they judge that the sticker has become too dirty, they will remove it. Since the removal of the sticker depends on the user, this solution is more versatile to differing levels of cleanliness and therefore applicable to a wider range of people. These stickers, however, cannot remove any obstructions in the nozzle of the bottle. But combined with other concepts, ketchup residue in and around the nozzle can be minimized, improving sanitation and preserving the precision of the nozzle.

**Remedial Solution (Cap Cleaning Brush with Redesigned Cap):**

The first concept solution is a brush that has properties that make it ideal for cleaning a ketchup bottle cap as well as a redesigned cap that contains a slot storing said brush. This brush would have a thin, horizontal disk about the size of the nozzle attached in the middle. This disk would be used to push down pieces of ketchup still in the nozzle, clearing the nozzle. In addition, at the end of the needle, there would be a brush that would allow cleaning of not just the interior of the nozzle, but also the exterior. The brush would be vertically cut, with one side having strong, rigid fibres, while the other would have soft fibres. The vertical cut allows precise cleaning for both rigid and soft fibres by using the end of the needle for both fibres. The rigid fibres would help clean up dried ketchup while the soft fibres would help clean up wet ketchup.
This concept does not affect the usability of the ketchup bottle, since the bottle is still used the same way. In clearing the nozzle opening, using the cap is relatively simple as the insertion of the needle into the nozzle is all that is needed. In cleaning the exterior of the lid, the needle would be used just as a brush, and therefore is also relatively simple. There is one issue in this design, in that the cleaning brush would need to be cleaned periodically. However, with this concept, there is still an overall reduction in effort spent cleaning the lid.

### Pugh Chart

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>Frictionless Pointy Cap</th>
<th>Cap Cleaning Brush with Redesigned Cap</th>
<th>Cap Vent System</th>
<th>Ketchup Bottle Stand</th>
<th>Quick Cleaner Stickers</th>
<th>Reference (Current Lid)</th>
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Key Design Decisions:

- Clearance height
  - By implementing a stand that has no moving parts, the height clearance must be at least tall enough to enable a person to fit their hand underneath the stand. Furthermore, the height should also allow for a hand accompanied with food to be comfortably inserted underneath the stand (for example, a hand holding a hot dog). Additionally, the height between the bottom support and the top support of the stand should allow for hands to fit around the ketchup bottle to squeeze. The hand breadth and length for the 95th percentile male is 9.7cm and 20.7cm respectively. Therefore, both heights mentioned previously should be able to accommodate for these measurements.

- Supports
  - The stand support structure should be able to support the load of a full ketchup bottle and also keep it positioned vertically upside down so that the only effort input required of the user to apply ketchup is to squeeze the ketchup bottle.

- Shape of base
  - The length between at least two of the legs needs to be able to accommodate at least a common dinner plate, which has a diameter of around 30cm, in order to fit plates of as many sizes as possible underneath the stand. Furthermore, the actual shape of the base should be a shape that allows for the width stated previously, but occupies as low space as possible. Therefore, the recommended base shape is an isosceles triangle with a short height, so that the stand is small, yet stable. Furthermore, by having three legs as opposed to more allows for the largest possible space between legs to accommodate for the average dinner plate of about 30 cm in diameter, while taking up minimal surface area.

- Material
  - The stand needs to be able to hold the load of a 1.5L ketchup bottle, in addition to other possible condiments. Therefore a strong material is needed for this stand, such as stainless steel, which as opposed to a cheaper option like plastic, is both stronger and more resistant to deformation. Stainless steel has a yield stress of about 400 MPa which varies based on the composition of the alloy. Also, unlike plastic, its yield stress is not strongly affected by fluctuations around room temperature.
  - The inside of the nozzle of the new pointy cap should be frictionless, as stated above in the introduction of the solution. Therefore, a material like LiquiGlide should be used.

- Presence of shelf
  - Due to the fact that the length between the two legs should be able to accommodate a common dinner plate, as stated above in the “Shape of base” section, there will be some leftover space on the base of the stand, due the difference in areas of the ketchup bottle and the actual area of the base. Therefore, a use for this extra area should be designed. Our recommendation is to use the leftover space as a shelf. This shelf can be used to store other condiments, which would minimize the space that the stand alone takes up (for example, in the case of a dining table, salt and pepper shakers).

Holistic and Analytic Description:

Based on the holistic evaluation of our candidates, the stand was found to be the best solution as it likely has the longest lifespan and is the most durable as a result of the material selected. An analytic evaluation of the parts revealed that it was the most expensive solution because of the choice of stainless steel to make all the parts. However, the stand is highly usable as it can be just as easily used by people of all different hand sizes. Because the weight of the bottle doesn’t need to be supported or stabilized by the user, precision of use of the bottle with the stand is also improved. The presence of the shelf as part of the stand has both negative
and positive aspects. The shelf limits the height of the food that can fit under it for ketchup application and also makes the stand take up a lot more space than the ketchup bottle itself would take up. However, the shelf can also be used for storage, allowing it to double as a table organizer. Although other solutions are cheaper and smaller than the stand, the usability and precision the stand brings to the application of ketchup from a bottle make the stand the best solution.

References:


