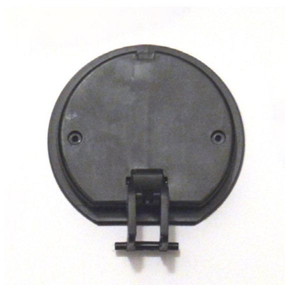

Electric Kettle

Toastmaster 1.7L Kettle

How Things Are Made Tear Down Project
51-341 Fall 2020

Janet Peng

Polymer Toastmaster Electric Kettle

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Product History
+ Evolution

Kettles have been dated back to as old as 3500 BC. Stemming from a need to boil water (for tea) and cook food, they have made an appearance across various cultures from Russian samovars to Silver teapots from England to Ancient Chinese porcelain tea kettles.

Before polymer kettles more similar to the one explored in this project, kettles were made of metals or ceramic. The heat resistance of metal afforded them to be hung or placed over open fire as a simple way to heat water or cook food. Ceramic being light in weight and chemical stability even at high temperatures made it a good material for kettles as well.

Silver Teapot

Copper and Brass Samovar

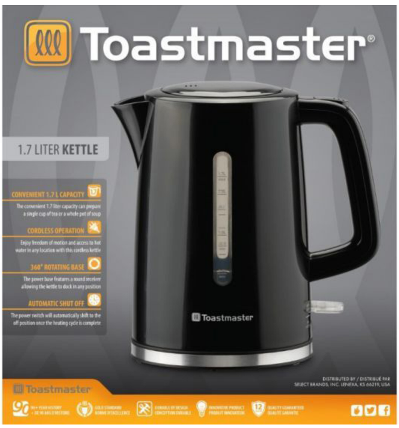
Porcelain teapot

Nowadays, electric kettles are mostly made of metals (steel, iron, silver, aluminum) for their thermal conductivity and heat-resistance, heat-resistant polymers (LDPE, PP, PS), or a combination of the two. They are usually composed of some sort of vessel for the water and a metal component at the base for the heating elements.

The overall shape of the kettle has remained relatively unchanged over time. The common parts of a kettle include a lid, spout, handle, and some sort of body that acts as a vessel for the water.

Toastmaster has a few other versions of electric kettles. Their more premium version has a glass body with a polymer handle and metal covered base. The material of this product makes it feel more high quality and is also more costly to produce. Their other polymer kettle is their low-cost kettle. It has no extra metal decorative pieces and is slightly smaller than the one explored in this project. The use of only polymers creates a softer feel and the amorphous and asymmetrical form speaks to this material difference. Based on product availability and images online, the full polymer kettle seems to be their oldest model.

Glass, metal, polymer (~$50)



Polymer, metal (~$20)
Variant explored in this project

Same kettle without the metal strip

Polymer (~$15)

Part + Process Breakdown

70 parts

Metal

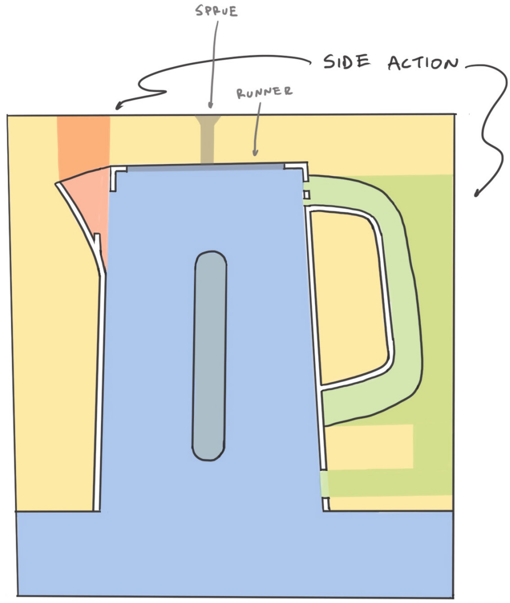
- 18 Steel screws
- 4 Copper screws
- 4 Stainless steel springs
- 4 Stamped stainless steel
- 1 Cast stainless steel
- 1 Stamped steel
- 2 Stamped brass
- 5 Stamped copper
- 3 Bimetallic strips
- 1 Nichrome wire
- Copper wire

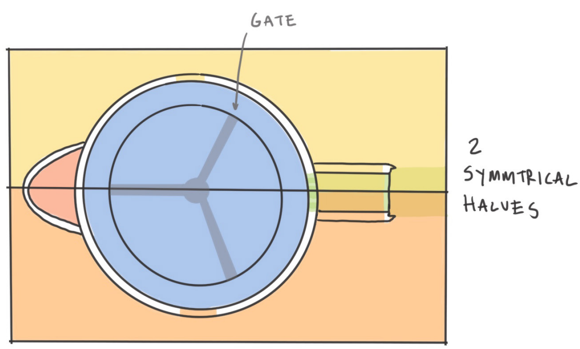
Polymers	23	Injection molded polypropylene
	1	Injection molded silicone
	2	Compression molded silicone
	1	Cut polymer mesh

Manufacturing Process

Most polymer parts in this product are designed to be injection molded. This is a rapid, cost-effective, high quantity manufacturing process. Pieces are designed to be made in simple two part molds and most are arranged using a runner system so that multiple parts can be shot at once.

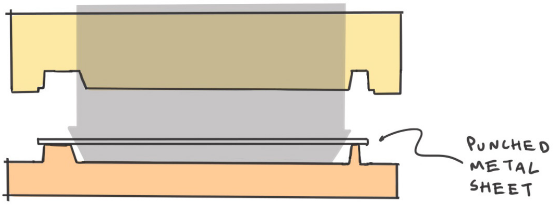
Compression molding is mainly used to produce the elastomer gaskets in this product.

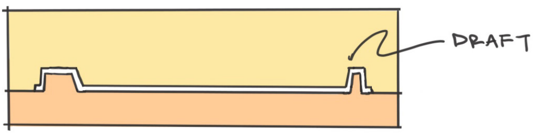




The most complicated injection molded piece is the body of the kettle. Although designed to avoid complexity, the piece still needs a five part mold with side action in order create its geometry. The gate of the piece is at the opening where the lid will be placed so that when fully assembled, it can be hidden.

Most metal parts in this product are formed from metal sheets. More specifically, stamping metal sheets creates most of the metal parts. Like injection molding for polymers, stamping is a fast, cost-effective, high quantity manufacturing process. The main metal pieces are the steam tube and the heating element enclosure. The enclosure was punched and stamped while the tube was seam welded from a sheet.





Materials

The majority of this project is made of injection molded polypropylene (PP). This material works well in this application as a colorable polymer that is relatively hard and heat resistant and is often used on food related consumer products. It's light, cost-effective, easy to mold and manufacture and thus can produce a wide range of designs and shapes.

For the price, this is the best material choice. However, compared to more expensive materials, polypropylene does not maintain heat as well as its metal counterparts and there is a general concern over BPA and other toxic chemicals contaminating polymer water vessels.

Although most pieces are polypropylene, elastomers, metals, and other polymers are used in places where polypropylene cannot achieve the same result. For example, elastomer gaskets are needed to create hermetic seals and the stainless steel heating element enclosure needs to be much more heat resistant because of it's direct contact with the heating nichrome wire.

Polypropylene (PP)

Low-cost, light

Easy to injection mold, can color

Good heat and chemical resistance compared to other polymers

Chemically inert

Doesn’t absorb much water

Polyvinyl chloride (PVC)

Good electrical insulator

Silicone

Food safe

Can create a hermetic seal

Thermoset plastic

Strength in high temperature applications

Stainless steel

Corrosion resistant

Visually appealing

Steel

More cost efficient than stainless steel

Creates a bimetallic strip with brass

Copper

Good electrical conductor

Brass

Good electrical conductor

Creates a bimetallic strip with steel

Assembly + Joinery

This product uses molded in geometries to assist in the assembly of parts. It also uses elastomer gaskets and friction to help tightly fit pieces together. By using few mechanical fasteners (such as screws) and welds, the product can be assembled faster and more easily.

Welding is used in this product to join like materials permanently while creating an air tight seal. Mechanical fasteners are used to more securely fasten two pieces together (compared to relying on snap fits only).

This product was likely assembled by factory workers by hand. The direction of fit for many parts do not seem like they can be automated.

Welding

Seam welding	Creates tight permanent seals
Spot welding	
SMAW welding	
Ultrasonic welding	

Mechanical Fasteners

Phillips head	Non-permanent joinery
Tri wing	Strong and fatigue resistant
Self Tapping	Used to join metals
Flat point	

Snap Fits

Molded in receiving and protruding geometries that fit together

Easy to assemble

No extra parts

Rotational Mechanisms

Molded in receiving and protruding geometries that fit together and rotate

Easy to assemble

Molded in mechanism for reduced parts

Physical Slots

Molded in receiving geometries (such as ribs) that accept other parts

Help hold pieces together during assembly

No extra parts

Weaker non-permanent attachment

Friction

Elastomer gaskets	Easy to assemble
Tight fit pieces	Can create a hermetic seal

Sustainability

Most of this product is made out of polypropylene which is a recyclable thermoplastic. As well, the filtration piece at the kettle’s spout can be easily removed and replaced overtime. These considerations make the product ecologically sustainable.

However, polymers are not biodegradable and are generally not the most ecologically sustainable materials. As well, the product is not designed to come apart and back together to be fixed and replaced over time, making it an object that is likely to end up in landfills after some use.

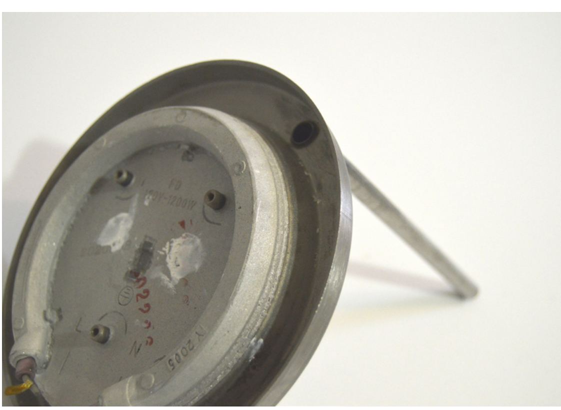
Existing DFM + DFA

Limit screws and use the right material for each application

Example: stainless steel on lid but zinc anodized steel elsewhere

Lever opening at the parting line reduces need for side action

Built in geometries for assembly and reduced parts.



Design metal pieces to be stamped

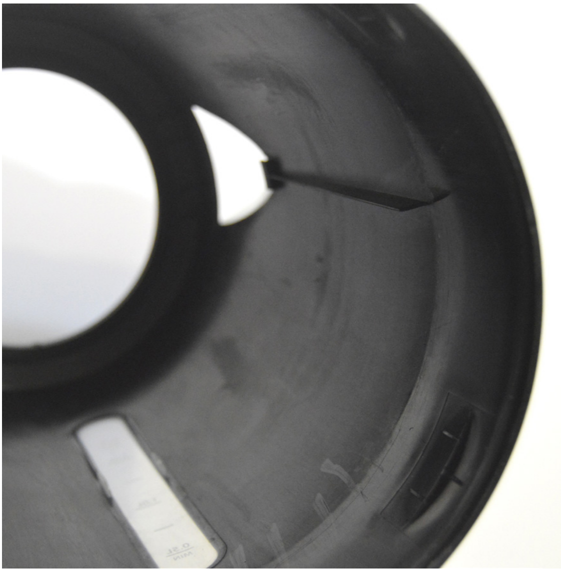
Design polymer pieces to be injection molded

Friction fit pieces together to avoid adhesives or welding

Example: insert at base holds mechanism, gasket holds heating element in the body (lubricant used to ease assembly)

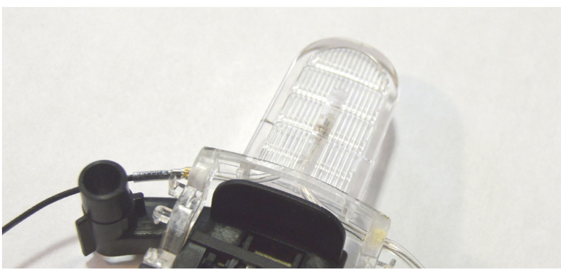
Design parts to fit together for ease of assembly (and assemble with gravity)

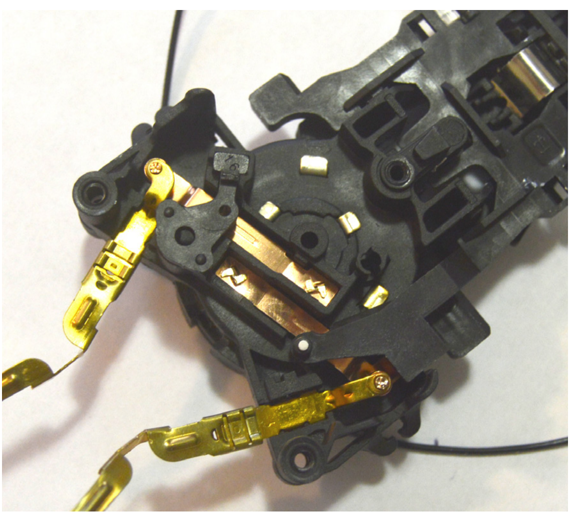
Example: prongs on steam tube holder piece helps hold it while lid mechanism is assembled



Design parts to assist slotting pieces into others

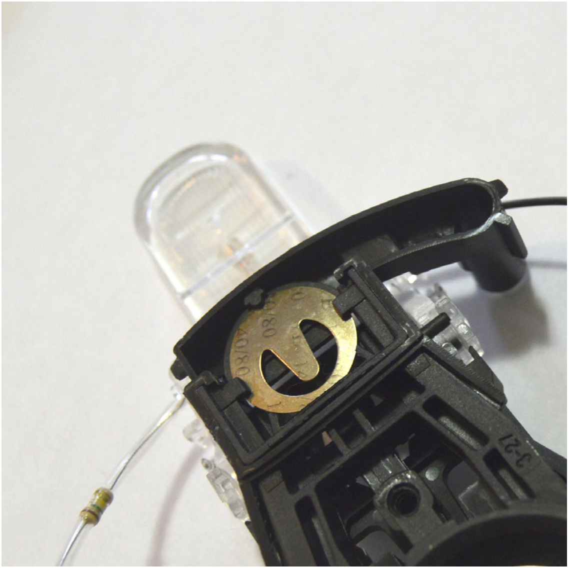
Example: wings on body window, protrusions for filter to fit into, slot in lever for LED to slide into





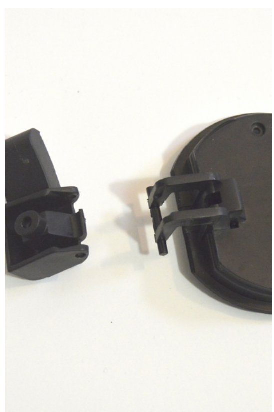
Design parts to fit and stamp together

Example: steel conductor piece has flanges at the bottom that slot into the polymer piece. It is then stamped to mechanically secure the pieces together.



Design inserts to slide in different pieces instead of using fasteners or adhesives

Example: bimetallic strip



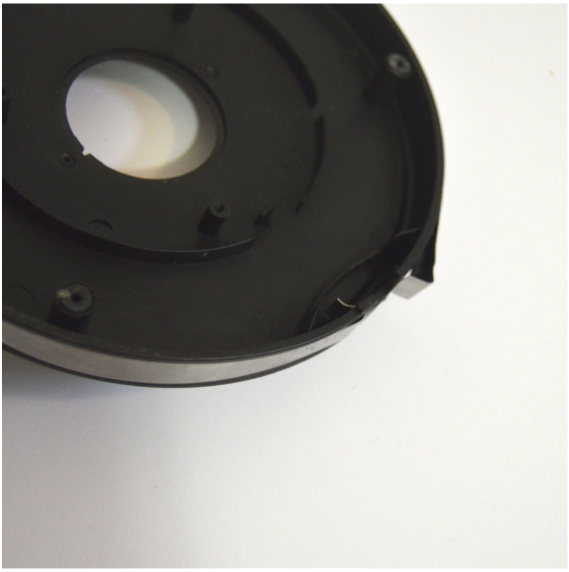
Design mechanisms to snap together for ease of assembly

Example: rotational mechanisms at lever and lid

Proposed DFM + DFA

01 Remove the decorative metal strip wrapped around the base.

This reduces the number of parts and operations. If the visual quality of the strip is important, consider using a polymer to replace the metal.



02 Remove of one of the clear windows welded into the product's body or make the entire body out of some translucent polymer.

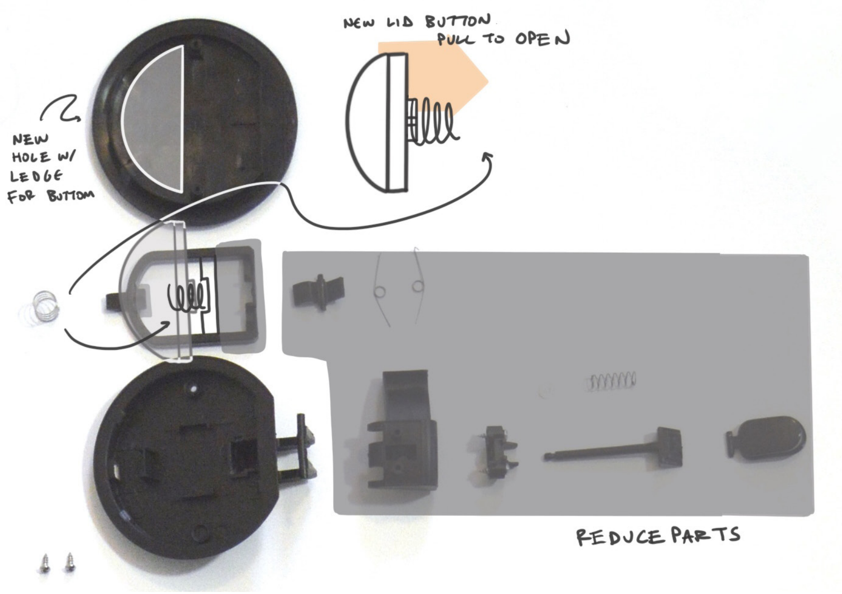
This reduces the number of parts and operations.

03 Mold the steam tube holder into the body.

This reduces the number of parts.

04 Simplify lid mechanism.

The current design uses 6 polymer parts and 4 springs to translate motion from the handle to the lid. Other lid opening mechanisms can be produced with fewer parts.



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CMU 51-341 Lecture Slides

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