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Thermally-efficient Tea Set Design

Thermally-efficient Tea Set Design

Hawraa Mousa Almaqseed

This thesis is dedicated to my mother and father for their continual support and endless encouragement.

ROCHESTER INSTITUTE OF TECHNOLOGY

SCHOOL OF DESIGN

COLLEGE OF IMAGING ARTS AND SCIENCES

MASTER OF FINE ARTS IN

INDUSTRIAL DESIGN

THERMALLY-EFFICIENT TEA SET DESIGN

BY

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Abstract

Understanding the importance of tea in our daily life and provides in depth research on the history of tea, the culture behind drinking tea, the benefits of drinking tea as well as some key statistics involving the world tea consumption.

Various health hazards of drinking hot tea or cooling the tea by blowing air from the mouth have been listed at length. This, in turn, throws light on the necessity of coming up with an innovative design for the teapot, teacups, and the accompanying items i.e. the teaspoons and the saucers.

Prior to designing the tea set, various materials for the making of the tea set have been analyzed along with the study of the evolution of the tea sets and their design across centuries. For this thesis and the tea set designed, the prominent designer whose work was researched was Christopher Dresser, the 18th century modern designer who is thought to be the forerunner of modern design built on form, simple linear design, and function.

The design process involved extensive brainstorming and developing the design mock-ups for the tea sets. With the identified design guidelines in mind, the most suitable design was then finalized. The actual modeling was done through the use of 3D printing, which helped substantially reduce the time for prototyping.

This document provides the details of the project along with information on the background research, the methods followed, and the results of the various studies done.

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Introduction

Components of Thesis

The benefits of tea drinking have been discussed at length, along with the demand for tea worldwide, and in some of the major countries. The effects of blowing tea to reduce the temperature have been listed. With the noted negative effects of blowing, which are discussed in the thesis, developing a healthy and adequate solution for tea consumption was the primary goal. Through various analyses, design, and development, the solution that was created, the functionally innovative teacups are made to ensure that people drink tea at the perfect temperature. This eliminates the necessity to either settle for lukewarm tea or blow the tea to decrease its temperature, a procedure, which is later discussed as harmful.

Necessity of Thesis

As early as 2700 BCE, tea has been regarded in China as a drink with powerful medicinal properties. The renowned Chinese surgeon Hua Tuo, incidentally the originator of anesthesia, wrote about how drinking tea enhanced concentration and alertness (Chow & Kramer, 1990). In the Chinese book *Cha Jing*, Lu Yu wrote,

"Tea tempers the spirit and harmonizes the mind; dispels lassitude and relieves fatigue; awakens thought and prevents drowsiness; lightens and refreshes the body and clears the perceptive faculties" (Serena Hardy, 1979).

Lu Yung has recorded the various benefits of tea as:

- Tea is of cold nature and can be had in case of constipation.
- Tea is best to be drunk when the flavor is at its coldest nature.
- If a person is generally feeling either hot or warm, feeling melancholic, suffering from brain ache, eye irritation, pain in the limbs or in the joints, drinking tea four or five times

a day can alleviate many of these symptoms and, in some cases, the underlying causes (Ukers, 1935).

Ancient Chinese literary works mention the various benefits of drinking tea; these health benefits include improved blood flow, which leads to enhanced resistance towards a wide range of diseases, as well as decreased risk of fatigue and depression (Chow & Kramer, 1990). Tea drinking also helps in removing alcohol and other harmful deposits from the body (Chow & Kramer, 1990). Tea consumption is known to assist in improving digestion, brightening the eyes, and reducing the effect of summer heat on the body (Chow & Kramer, 1990).

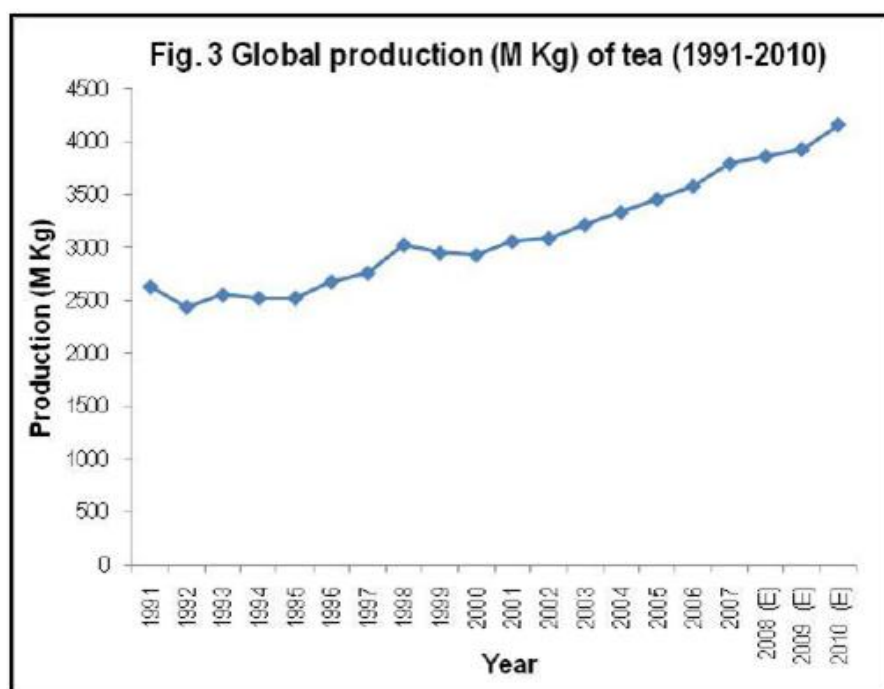


Figure 1: Global tea production

The global market for hot coffee and tea is forecasted to reach \$69.77 billion in US currency, and 10.57 million tons, in terms of volume, by the year 2015 (GIA, 2011). One of the main reasons for its increasing popularity is the medicinal properties and health benefits that have been credited to drinking tea. There are numerous research reports, journals and other

publications describing the benefits of tea, and its' ability to protect against serious diseases such as strokes, cancer, and heart problems. Tea is absolutely free of calories, sugar, or fat (Ukers, 1935). In fact, green tea has ascorbic acid, vitamin B, potassium and other important minerals (Ukers, 1935). These health benefits, along with the taste and flavor, contribute to the growth in tea consumption worldwide.

<i>Tea consumption statistics [20]</i>	
Number of men and women around the world drinking tea every morning	2 Billion
Total projected sales of tea for USA in 2012	USD 15 Billion
Number of cups made from one pound of loose tea	200 cups
Tea produced every year worldwide	3000 million tons

Table 1

Though tea is highly popular, consumption at a very high temperature can be harmful to the body. Any drink ingested at high temperature raises the temperature of the stomach contents. Ingesting any liquid at a high temperature causes your heart rate to rapidly increase; it causes the blood vessels across the skin to expand, and there is an increase in perspiration as the brain switches on the various temperature regulators on the basis of the body's physiological feedback (Whitney & Sizer, 2008).

Goals

It is important to note that ensuring taste and flavor of the tea is a very important to the research. In order to be sure that the tea is at a temperature ideal to drink, the surface temperature should be reduced while at the same time ensuring that the temperature is maintained at the

bottom of the cup. This would then allow the individual drinking the tea to better enjoy it until completion, without having to worry about the temperature of the tea.

The teacups were designed keeping these objectives in mind, but the design conveys the historical significance of tea drinking while at the same time creating an aesthetically modern appeal. Different materials were shortlisted such as glass, clay, porcelain, and finally, ceramic was chosen as the medium of choice for designing the teacups.

Limitations

Tea sets have been a major part of many cultures for thousands of years. It would be impossible to explore every alteration and design of tea sets. This project focuses on the more common, contemporary, and mass produced tea sets as well as some renowned experimental designs. This project does not introduce new materials in the ceramic of the tea sets, as much as it simply introduces an altered design for better heat dissipation. Any future project, conducted by other students, could certainly explore changes in ceramic or material used. Another limitation to note is the inability to rely on slip casting for production as opposed to 3D printing. The design of the teacups is highly intricate in order to accommodate for the cooling system; slip casting doesn't allow for the specific shape of the teacup. Taylor (2011) states, "Making molds for slip casting requires a certain degree of accuracy" which makes it difficult to create this specific type of design.

Thesis Background

History of Tea

Tea is the second most popular beverage right after water, consumed by people across the world (Chow & Kramer, 1990). Historically, the discovery and consumption of tea can be dated as far back as 2737 BC (Chow & Kramer, 1990). As per Chinese legend, Shen Nong – the Divine cultivator discovered tea accidentally (Chow & Kramer, 1990). According to the legend, Shen Nong was boiling water when the leaves of a tea plant fell into the boiling water (Chow & Kramer, 1990). Shen Nong drank the new concoction which had a pleasant aroma and delicate flavor (Chow & Kramer, 1990). He experimented extensively on it and found that tea has medicinal properties too. This led to tea being a major beverage of choice in China (Chow & Kramer, 1990).

By the third century AD, tea was cultivated in Szechwan and also was incorporated into the ancient Chinese dictionary by Kuo P'o (Chow & Kramer, 1990). In those days fresh, tender tea leaves were picked and made into cakes under high pressure. The cakes were roasted till the color changed to reddish brown. These roasted cakes were crumbled and added to water along with onion, orange and ginger. This mixture was boiled and consumed as an herbal soup because of its remarkable cure against many diseases.

During the Jin Dynasty, (265 -420 AD) tea drinking spread to the rest of the parts of the country. In Tang Dynasty (618-907 AD), tea drinking evolved into an art.. Cha Jing by Lu Yu is the first book on tea written in the 8th Century AD (Ouyang, 1998). The book contains information on all aspects of tea growing and brewing known at that time. The book also contains details on the utensils and equipment needed for making tea and serving it. This book led to enhancing the popularity of tea in the neighboring countries of Korea, Japan and Southeast

Asia (Ouyang, 1998). Lu Yu is credited to equating the ritual of preparing and drinking tea to harmony, and order in line with the ideals of the cosmos and society (Ukers. 1935).

Japan found tea and Buddhism during the early part of the Heian period (800-1185 AD). The monks travelling to China to study Zen introduced tea to Japan. Initially its drinking was restricted to the monasteries and the aristocracy, but later on through the work of Eisai (1141-1215) it was introduced into Japanese homes in powdered form. Tea making reached ceremonial heights in Japan and the principle of Chado or, “the way of tea” was established. Japanese art and lifestyle revolved around tea and tea-ware. The opening of Japan, to international trade, in the 19th century encouraged the design of tea implements around the tastes of the Western markets.

Tea import started in Europe sometime in the 16th century. As the habit of drinking tea became popular, teacups, teapots and other Chinese ceramics were imported as ship ballast. These products were sold at huge profits because of the demand, in turn, leading to the Chinoiserie phenomenon. China was the sole provider of tea for the world till the 18th century. In the beginning, tea was consumed as a remedy in the West. In time, England saw the establishment of coffeehouses, which served tea and coffee only for men. As the demand for tea increased even among the common people, there was an increased focus on creating tea wares which would reflect the culture and times of the region. This led to an increased interest in the Chinese art of porcelain making in Germany during the 18th Century.

America got its supply of tea from the Dutch, and caught on to the habit of drinking tea within no time. America had a higher demand for tea than England. The English Parliament put in place legislations requiring America to import tea only from England, which led to smuggling, exorbitant taxation, and eventually the American Revolution for Independence.

Britain introduced tea plantations in the northern part of India, and subsequently to Sri Lanka. Currently, the world tea demand is catered to by India, Sri Lanka, Japan and parts of southern Asia. Chinese production is primarily for their internal consumption. Thus the journey of tea traverses medicine, philosophy, economy and spiritual zones.

History of Teacups and Teapots

In Cha Jing, Lu Yu listed more than twenty four items that are needed for the preparation of tea. Tea preparation and serving equipment comprised of items needed for roasting and powdering of the tea cake, stove to boil the water, and cups to serve tea. The brazier could be made either of brass or iron, and the shape was defined like that of a Ding's (as shown in figure 2). The three legs represent the three elements – water, wind, and fire as per Chinese culture (Sen Soshitsu, 1998).

During the Tang Dynasty, tea was in the form of teacakes in order to ease transportation. But during the Sung Dynasty, as earlier mentioned tea became an art, hence the refinement found its way into desinging of teacups too, and the connected items (David & Schapira, 1975). The tea was made using dried blocks of powdered tea leaves and mixing them with water using a bamboo whisk in large glazed bowls of rich, deep color. During the Ming Dynasty, the tea preparation process changed with the use of green tea, and a much simpler technique that brewed tea directly in the teapot. This gave rise to the use of teapots and their exquisite designs. The tea set came



Figure 2: Ding's Brazier

into being, and became an intrinsic part of tea drinking. The first teapots designed for brewing tea leaf were created in the 16th century at YiXing. These were primarily unglazed.

The early teacups were without handles, and had a bowl like appearance. The size of the cup was about 4.0 to 4.4 cm in diameter, so it could fit in the palm of the hand (Palmer. 1998). The tea was prepared and served in the bowl itself during the Tang Dynasty. In the Song Dynasty (960 -1279 AD), the tea bowls were dark colored with streaked glazing to suit the gray-green concoction. The preference to white glazed porcelain cups occurred during the Ming Dynasty(1368-1643 AD), when green tea was used and the tea making process changed (Clark 1989).

Yi Xing teapot is known as the best teapot for maintaining the aroma and the taste of the brew (Chow & Kramer, 1990).The clay used to make the teapot is from Yi Xing's deep earth. This is porous and the ceramic absorbs the tea fragrance with each brewing. Continued usage for brewing enhances the flavor, scent, and color of the tea. This teapot is never washed and is very small in size so that the tea is fresh, hot, and strong. The handles, spouts were added much later along with motifs depicting auspicious messages (Clark, 1989).

As the English love to add cream and sugar to their tea, Robert Adams' tea set contained the teapot, sugar holders, milk or cream containers, teacups, and teaspoons. The teacups are made of porcelain and have a translucent look. In modern England, there are many companies which manufacture exquisite tea sets such as The Royal Doulton and Limoges.

The current day tea sets are made out of different materials – porcelain, glass or pottery. The best quality tea set is from Jin DeZheng – the porcelain capital. The pottery capital is Yi Xing. The designs on the porcelain tea sets not only depict beauty, but also calligraphy.

Essentially there are two basic designs for the teacups involving the pedestal and flatbottom. For the teacup itself there can be about 15 different shapes ranging from fluted, scalloped, ribbed to basic rounded or straight sides. The teacup handles are distinctive, with different designs such as angular, serpentine, ring, D-shaped, and curled. Other than this, teacups can have decorative designs done both inside and outside of the cups.

Teacups in other cultures

The first small teacups specifically made for drinking tea in Europe were exported from the Japanese port of Imari. The tea bowls from the Far East did not have handles, and the initial imitations in Europe made at Meissen had no handles either.

A teacup usually is typically small with a small handle so as to grasp with the thumb and one or two fingers. The most common material used for making teacups is porcelain “china”. A tea set comprises of a cup and a small piece of dishware called the saucer. It might sometimes have the remaining items too, such as the teapot, covered sugar bowl, cream jug, and slop bowl en suite. In the western culture, the teacups are wider and shorter than the coffee cups. In the eastern culture teacups are narrower and taller than the coffee cups. But the point to note is that there is no constant shape, the design might vary in either of the cultures.

Green tea is famous in East China, while in the West it’s Earl Grey. Tea is prepared on many different occasions such as a family get together, at an auspicious occasion or function, as a sign of respect, apology, and many more. In England black tea is had with scones, milk, and sometimes strawberry jam. As the English drink their tea very hot, they came up with a solution – by adding a shallow bowl along with the cup. This shallow bowl evolved into the saucer later on.

The Japanese use small 7 oz teacups with handles, some of the teacups have built in lids and strainers too. They also prefer the pottery type or ceramic handle-less teacups sometimes. The cups are small about 3.5 – 5 inches tall with/without hand painted designs ranging from flowers, geisha girls, poems, nature etc.

In Tibet tea is served with butter, and it's an essential part of an everyday diet. There are different types of tea sets in Tibet such as:

- Geyu – the porcelain teacups
- Ebo – the silver teacups
- Yandchii – the jade teacups
- Xingpo – the wooden teacups

The most common teacup used is the Xingpo as it is easy to carry. The cup is made of birch tree usually. The wooden teacup helps in preventing scalding of lips and makes the tea more delicious [8].

In Arabic culture, the type of tea that is most commonly served is chai, black tea, green tea, peppermint, lemon, and chamomile. The tea is prepared in a kettle, and after it comes to boil, it is served in a small transparent glass cup. The black tea is usually prepared with milk and cardamom to add to the flavor of tea. The tea is served along with a selection of nuts, dry fruits, or sweets such as baklava.

In Morocco, people drink sweet mint tea throughout the day. It is essentially green tea with mint leaves. The tea is served into tiny palm sized glasses poured from large steaming copper kettles at arm's length. Here, the glasses are usually very colorful and festive, with lot of intricate details.

In the USA, tea is made with ice and a squirt of lemon. One can have iced tea either canned or bottled from the vending machines as well.

Some of the teacups from different countries have been identified for their design uniqueness and usability can be seen in the figure 3.



Figure 3: Teacup Designs

Research Field Trip

The first place selected for the research field trip was Kuwait my home country. Kuwait is known for its culture of hospitality built around serving tea or coffee (Harvard University, 2013). There is no specific time or place for drinking tea in Kuwait. People drink at home, workplace, while visiting friends, relatives, and numerous other social occasions. In every home or office there would be a teapot with freshly brewed tea to serve to guests. This tradition of offering tea to guests has come down from the Bedouin Tribe (Harvard University, 2013).

The Kuwait population comprises of the townspeople and the Bedouins (Mohammad, Xue, Evison & Tyler-Smith, 2009). The Kuwaiti Bedouin customs are largely followed by the large number of Bedouin tribal descendants. This is the reason that the traditional tea ceremonies and men's councils are still adhered to (Rosenblum, 2009). The tea ceremony is primarily followed by the Bedouin tribe whereas the urbanized Kuwaitis might opt for coffee. As the Bedouins were essentially nomads moving and living in the deserts; they are more used to drinking and offering tea, whereas, coffee is preferred by people in the cities (Roeder Jr., 2005).

A tea or coffee sharing ceremony is usually followed while sharing news as per the Arab culture or for receiving guests or for offering solace (Roeder Jr., 2005). When guests arriving at home are offered it, it is a non-verbal message to the guests to convey that they are culturally competent, and that the host is pleased to have the guests at home to meet the family. Guests should not refuse the beverage offered, as it would amount to insulting the host and rejecting the hospitality (Harvard University, 2013).

Kuwaitis drink and offer different types of tea such as black tea, green tea, peppermint tea, lemon tea, herbal tea and chamomile (Harvard University, 2013). The tea is prepared in a kettle and is well boiled before served. Milk or cardamom can be added to black tea instead of sugar. The tea is offered along with some dry fruits, nuts or sweets such as baklava and is often followed by a cold drink (Harvard University, 2013).

The tea ceremony in the Arab cultures has a special meaning. Most often the tea ceremony is held as an offer of friendship and for welcoming guests (Morey, 2012). The tea ceremony can also be held during business meetings, for signing business deals or for sharing news within the household (Roeder Jr., 2005). Most often in Kuwait, the business deals happen at home. The guest is taken home unlike in other countries where the guest is taken to a

restaurant. When the guest arrives at home, the host would prepare freshly brewed tea for the guest. The wife/hostess boils the water and adds grounded tea leaves to the boiling water. Spiced mints and other suitable flavors are added to make tea (Roeder Jr., 2005). The tea is boiled for a lot of time before it is served.

For serving tea, a steel tray is used with glasses. The tray is placed in front of the guest. The host would be the last person to take the tea, only after all the guests have been served. Only after the tea is served would the business discussion start (Roeder Jr., 2005). If any news has to be shared, then the pestle noise which is made while preparing the tea is a sign to convey that the news is ready to be shared with the members of the group. All the household members gather at the place to share the tea and the news (Roeder Jr., 2005). Tea drinking is often associated with a sign of hope for the future.

Tea and coffee are an essential part of the Kuwaiti lifestyle. As alcohol is a forbidden drink in Kuwait due to Islamic customs, so tea and coffee are the preferred choices of drinks. Kuwaitis ways of leisure revolve around relaxing, eating, talking, and drinking tea or coffee. Even on a daily routine basis the tea drinking ritual is adhered to after every meal (Edelstein, 2010).

Kuwait also has the habit of afternoon tea – *chai eltha'ha* (Edelstein, 2010). Even now the tea is prepared in the traditional manner by heating water in *Samawer*, on top of charcoal, instead of the regular gas stove. The belief is that the tea boiled in *Samawer* is tastier as the natural taste of tea is better retained. The tea is boiled over a low flame so that it steeps nicely. The tea is served in wasp waisted glasses known as *istikans* (Edelstein, 2010). It is customary for the host to leave a thick layer of sugar at the bottom of the glass which is placed on a small saucer. At the time of serving to the guest, the tea is spilt intentionally as a symbol of generosity

of the host. The Kuwaiti tea glasses are ornate, usually with thin gold filigreed rim and are mostly wasp waisted.



Figure 4: Teacups in Kuwait

Turkey is the 6th largest producer of tea in the world, and that was the second place selected for the research field trip. The Turkish word for tea is Cay. Tea is an integral part of the Turkish culture. A sign of Turkish hospitality is offering guests tea. In fact, Turkish tea is the national drink in Turkey. Turkish tea is black tea which grows in Rize town in Turkey near the Black sea. There is no specific time or place for drinking tea in Turkey. People drink at home, in the workplace, or, while visiting friends, relatives and all other social occasions. As per Turkish folklore – conversations without tea are like a night sky without the moon!

In every home or office there would be a teapot with freshly brewed tea to serve to guests. The employment law/labor law dictates that in Turkey, it is essential to have at least two tea breaks within the working day. Turkish herbal teas are delightfully flavored the most common ones are apple, rosehip, Sage and linden flower.

Making a good Turkish tea is an art. The Turkish tea is brewed similar to the Russian *Samawer* method. Turks stack two kettles known as caydanlik – the bottom part contains the boiling water and the top pot has the tea brew.

The tea is stored in an air tight container so that external odors and humidity cannot cause it to spoil. The water should be lime-free. For making tea, a tea kettle and a porcelain teapot are ideal. Lukewarm water should be added to the kettle and one teaspoon of tea per person should be added to the water while boiling. Once the water has boiled, the mixture should be poured into the teapot. The teapot should be kept on top of the tea kettle on the fire so that it boils on the steam. The brewing process takes about 10-15 minutes.



Figure 5: Tea Sets in Turkey

The tea needs to be poured into small tea glasses, and the glasses need to be topped with the hot water from the kettle, depending upon the taste of the drinker. The Turkish tea glasses are ornate, usually with a thin gold filigreed rim, and are mostly tulip shaped. The tea is made with two or three beet sugar cubes.

Design Development Process

Before starting on the design process, the different pieces of equipment involved were studied from their utility perspective.

The teapot: The teapot is intrinsic to the hearth, home and symbolizes warmth, hospitality, and grace. It should be able to store hot water for a length of time without losing the temperature, and it should ensure that the flavor and essence of the tea does not escape too much. Without having to open it too much, because it might be in danger of cooling, one should be able to pour the drink out into cups without much spilling. It should be easy to handle and store.

The teacup: Raising a cup to the mouth brings the person close to the different senses of sight, touch, and taste. The teacup needs to be easy to handle, fit snugly in the hand, should be able to exude comfort and warmth while being graceful, true to tradition and at the same time contemporary in design, keeping in mind the current tastes.

The handle of the cup: The handle of the teacup should enable the user to easily lift and hold the cup. If the handle is too big then it would be awkward to hold, if it is too small, then the heat could cause serious burn on or around the fingers.

The saucer: The saucer is for enhancing the beauty of the cup and its' usefulness. It serves as tray to carry the hot teacup and if it is a bit large it can be used to hold sugar cubes, lemon wedges or the spoon to stir.

Design Rationale

Blowing tea and drinking it has been scientifically observed as dangerous for a person's. When air is blown on the hot food or drink from the mouth, Carbon dioxide is released from the mouth (Whitney & Sizer, 2008). This Carbon dioxide reacts chemically with the water vapor on the hot drink or food to form carbonic acid compounds, which are acidic in nature (Whitney & Sizer, 2008). The drink when subsequently would enhance the acidic level of blood. When the blood becomes acidic, the pH level of the blood decreases and this can even lead to acidosis (Whitney & Sizer, 2008).

Acidosis occurs when the blood is highly acidic, and alkalosis is the condition when blood pH level increases (Whitney & Sizer, 2008). Along with the decreasing of pH level in the blood, the breathing becomes deeper and rapid (Whitney & Sizer, 2008). The reason for this is the body tries to reduce the excess acid content in the blood by reduction in the carbon dioxide. This in turn would lead to extra effort by the kidneys to increase the acid content in the urine to maintain the balance (Whitney & Sizer, 2008). This situation can lead to different diseases such as diabetes, kidney or liver diseases. In some cases this might be fatal too (Whitney & Sizer, 2008).

Based on this scientific information and the possible health problems that can occur, along with the increased demand in the world for tea, there is an acute need for a solution which would help address this problem without spoiling the taste, flavor or the emotional comforts that can be obtained from drinking tea (Whitney & Sizer, 2008). The need is for a uniquely designed teacup which would ensure that the tea temperature on the surface is low, while the temperature at the bottom of the cup remains hot (Whitney & Sizer, 2008). This feature would ensure that the

person can drink the tea at optimum temperature without any danger of increasing the acidic levels of the blood (Whitney & Sizer, 2008). While at the same time the tea would not become too cold, because of the smart temperature maintenance at the bottom of the cup.

Design Process

A good design is a perfect marriage between utility and beauty. The tea set design was done keeping this in mind. In the beginning of the design process various materials were considered for the manufacture of the tea sets.

Initially the user perspectives for the tea set were explored. This involved capturing the needs of the consumers and the design preferences that can be explored. In this phase research was done on the different teas around the world, identification of the needs, understanding the aspects involved in tea making, and the implements used in different cultures.

After assimilating the research data and exploring first hand some of the tea cultures, the possible criteria were analyzed so as to incorporate them in the design mockups. This is a key phase of design process as mentioned by Donald Norman [22]; self-reflection is the key to solve design problems.

The vessels to brew the tea: The factors to consider while designing the vessel for brewing is that it should be versatile, simple to use, affordable, and should be able to extract good quality brew. To extract the best flavor from the tea, the pot should be able to retain heat for a long time, the pot should be spacious for the tea leaves to expand and the pot should be easy to handle.

Heat retention is dependent primarily on the material of the pot, and also the ability of the pot to stop the escape of heat. From research and experiments, ceramics, cast iron, porcelain, and clay are good for heat retention. When it comes to cast iron, it is better suited to use it for water

boiling than for tea brewing as it stains and might add on additional flavors which is not preferable. When other metals like steel or aluminum are used for boiling they tend to leach, which is a health hazard. Glass vessels would look good, but the heat retention is not high, and some people might not be able to withstand the very high temperatures needed while brewing the different teas.

Ideally, from the design aspect, a lid should be there to ensure that the heat of the brew does not escape and the tea tastes better. Another aspect to consider is if the vessel is filled only partially with water, the air inside the vessel will lead to heat loss, and if the heat is not sustained the flavors might not be extracted properly. Hence the size of the vessel should be big enough for the leaves to unfurl so that they can release the flavor, but at the same time small enough so that there will not be too much free space.

The teapot should also have a spout so that the brew can be poured out without having to remove the lid, and the spout should be placed so that the lid does not fall when the teapot is tilted. Some of the materials considered were copper, wood, plastic, and ceramic. These materials were considered on the basis of their thermal conductivity.

For drinking cups the ideal size is that a person should be able to enjoy the tea without having to blow on it for temperature reduction, and the temperature should be perfectly right until the cup of tea is completed. With this in mind, the ideal cup size has been decided. The material that has been decided for the teacups was ceramic, as the fragrance of the drink would be better.

After due study of the different materials, the ceramic saucer and spoon were modified and the material chosen for these two items was wood. The reason for this choice is that wood is

easier and lighter to carry in comparison with ceramic material, which are heavy to carry. Also, wood prevents transmission of heat from the cup to the hand as it acts as a thermal insulator.

The wood chosen was the cherry wood which was very soft and has a niche surface with distinctive tight grains. For finishing, non-toxic finishing products were used on the wood surface. A mixture of Beeswax and mineral oil was used for the finishing. Beeswax can be easily mixed with mineral oil and the resulting mixture smells very good too. The mixture also provides a water repellent finish. Mineral oil is by itself colorless, odorless, and tasteless and is inert in nature.

The teapot shape has been changed from a circular shape to a cylindrical shape so as to provide more space for the tea. The circular pot was designed for storing cold water only. The spoon and the saucer were designed to suit the intrinsic design elements of the tea set, and act as smooth continuation to them while maintaining the usability and the strength.

Design Experimentation

To experiment on the different possible designs, which would lead to a temperature reduction only at the surface level, while ensuring that the temperature at the bottom of the teacup remains hot, the following tools have been used at a preliminary level.

The tools:

- Metal
- Teacup
- Electronic Thermometer

The Experiment Constants

- Time: 2 minutes for each of the experiments
- Temperature: 70⁰ C



Figure 6: Experiment Situation 1

Experiment Situation I

In the first experimental setup, a glass with thick bottom has been taken containing hot tea at 70°C . The cup was allowed to stand without any human intervention for a 2 minute time period. After this time period the temperature of the tea in the teacup was measured.

Observation:

When the temperature of the tea was measured with the thermometer at the end of the 2 minutes time period, it was found that the temperature of the tea had reduced gradually at a very slow rate to 67°C .

Finding;

Without manual intervention, the temperature of the tea reduces at a very slow rate.

Experiment Situation II

In the second experimental setup, the same glass with thick bottom has been taken containing hot tea at 70°C . In this glass a metal spoon has been immersed. The cup along with the metal spoon was allowed to stand without any human intervention for a 2 minute time period. After this time period, the temperature of the tea in the teacup was measured.

Observation:

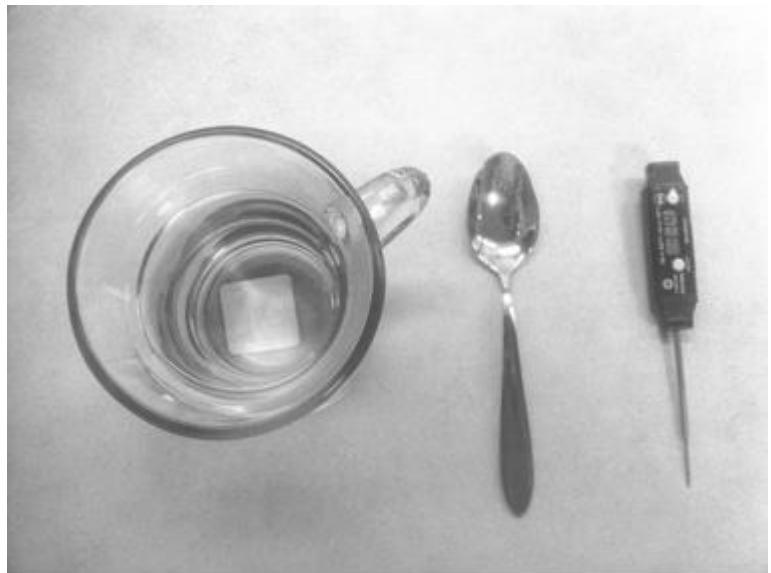


Figure 7: Experiment Situation 2

When the temperature of the tea was measured with the thermometer at the end of the 2 minute time period, it was found that the temperature of the tea had reduced drastically from 70°C to 55°C .

Finding:

This was because the spoon absorbed the heat of the tea and thus reduced the temperature at a high rate.

Experiment Situation III

In the third experimental setup, the same glass with thick bottom has been taken containing hot tea at 70°C . In this glass a metal cylinder has been immersed. The cup along with the metal cylinder was allowed to



Figure 8: Experiment Situation 3

stand without any human intervention for a 2 minute time period. The temperature of the tea in the cup was measured.

Observation:

When the temperature of the tea was measured with the thermometer at the end of the 2 minute time period, it was found that the temperature of the tea had reduced very fast in the beginning, and this decrease slowed in the end then measured 65°C .

Finding:

This was because the metal cylinder absorbed the heat from the tea and kept it at the bottom of the cup.

Experiment Situation IV

In the fourth experimental setup, the same glass with thick bottom has been taken containing hot tea at 70°C . In this glass a flat metal cylinder has been immersed. The cup along with the flat metal cylinder was allowed to stand without any human intervention for a 2 minutes time period. After this time period the temperature of the tea in the teacup was measured.

Observation:

When the temperature of the tea was measured with the thermometer at the end of the 2 minutes time period, it was found that the temperature of the tea had reduced gradually from 70°C to 67°C .

Finding:

This was because the flat metal cylinder absorbed a little heat from the tea and kept it at the bottom of the cup.

Final Observation and Finding

From the four experimental situations observed, and after going through the results, the metal cylinder was found to be the best solution to ensure that the temperature of the tea reduces at the surface, while the temperature at the bottom of the cup is still maintained at a higher temperature.

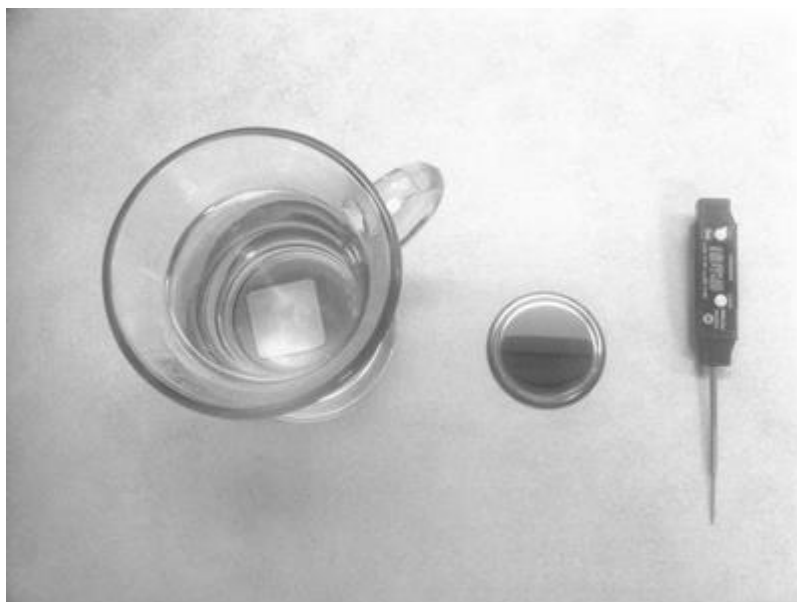


Figure 9: Experiment Situation 4

With this final observation, the design has to be planned after doing suitable modifications. The view of the metal cylinder designed for a glass in different views are as shown in the figures 10,11, & 12.

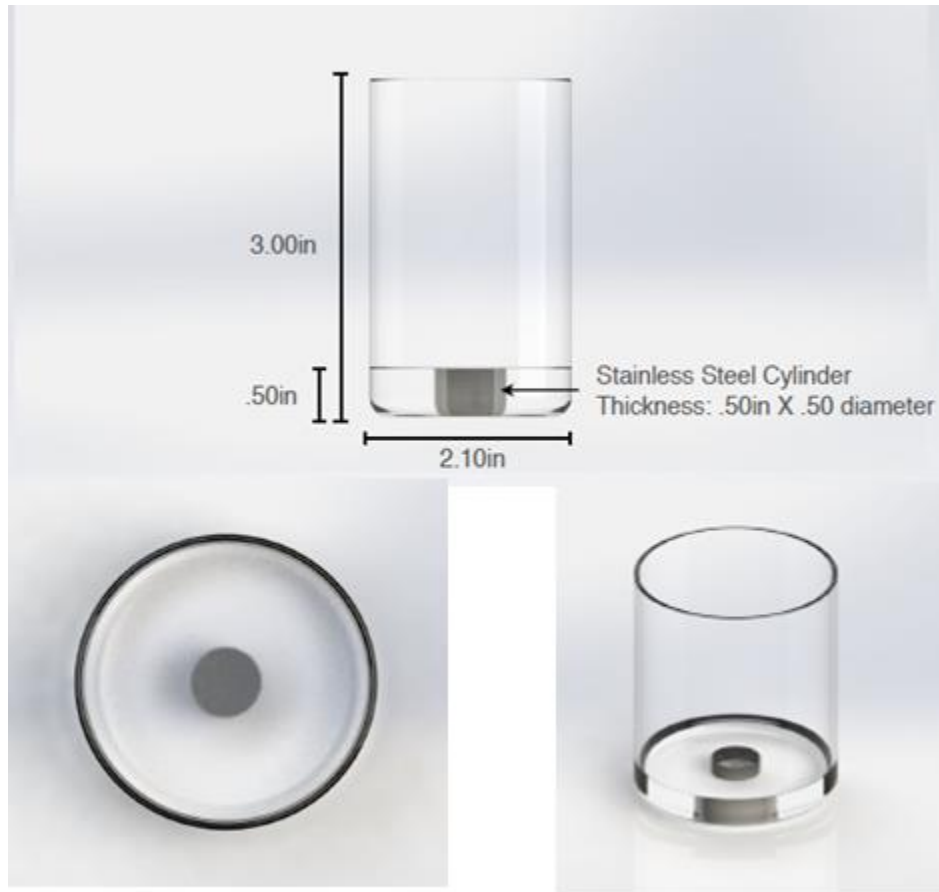


Figure 10: Experiment with stainless steel cylinder

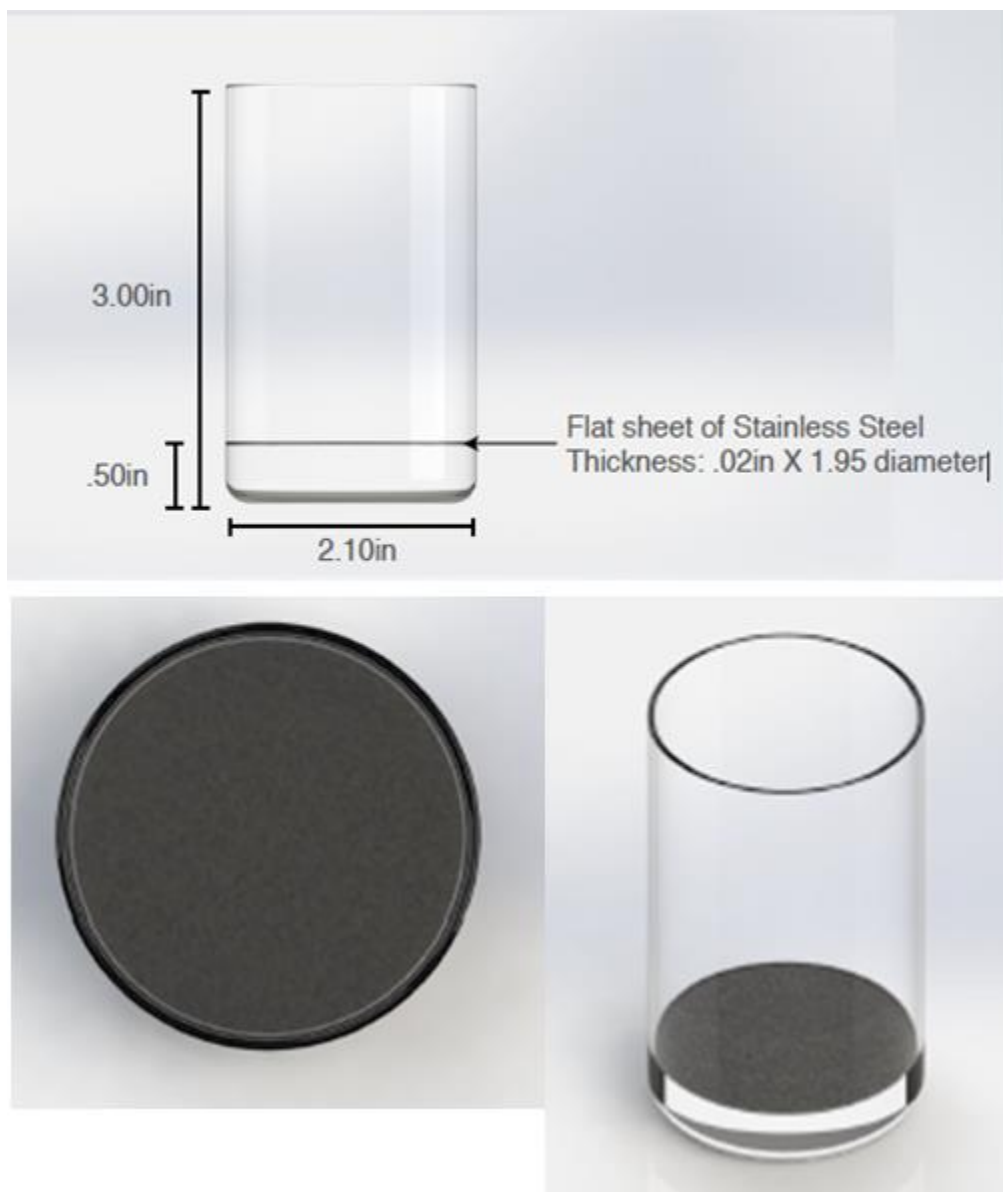


Figure 11: Experiment with stainless steel sheet

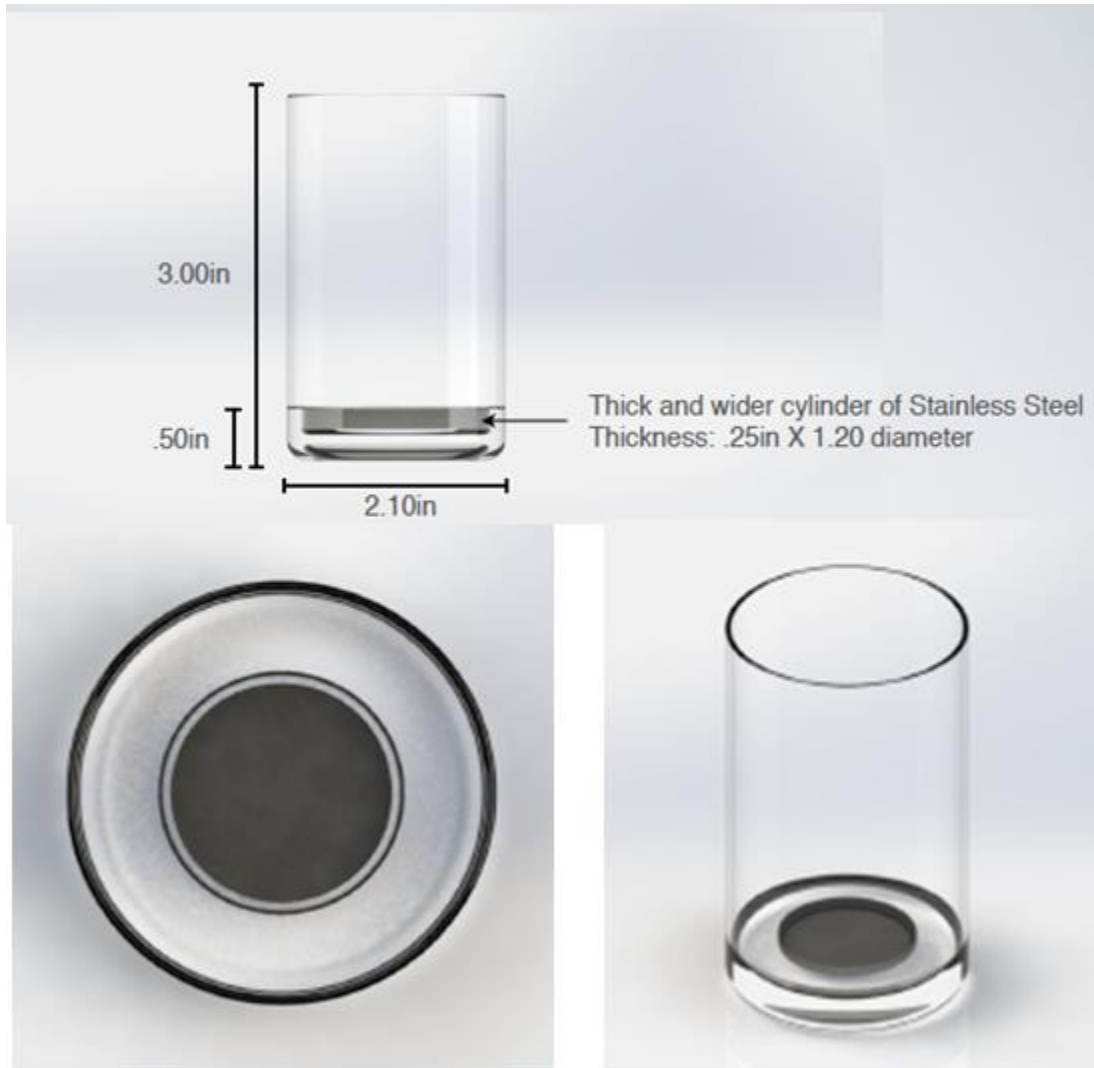


Figure 12: Experiment with stainless steel thick & wide cylinder

Design First Mockups: Teacups, Teaspoons and Teapots

Following the experiments and the initial design experimentation, the initial mockup designs were done for teacups, teaspoons and the teapots. A prototype, or a mockup design, involves conceptualizing a model either in scale or full size of the product. This stage involved the studying, testing and analyzing the manufacturing feasibility of the products.

In case of the design of the teacups, teaspoons and teapots as all the products are consumer products, the mockup design was done with focus on proving the design concepts,

evaluating the various options, testing the feasibility for product manufacture and most importantly the consumer's ease of use. The different iterations on the mockup design were done in accordance to the Usability Centered Design approach (Kim et al 2004).

The mockup designs were done using virtual prototyping through the use of software.

Virtual prototyping is the process by which a digital mockup is

simulated through the computer of the physical product, so that it can be presented, analyzed, and tested on the pertinent parameters such as the design, manufacturing feasibility and usability in the real world (Wang 2002).

Some of the possible form designs that have been done initially are shown in the following figure 13.

Some of the sketches of the teapot, teacups, their handles, spouts, teaspoons etc. can be seen in the figures 14, 15, and 16.

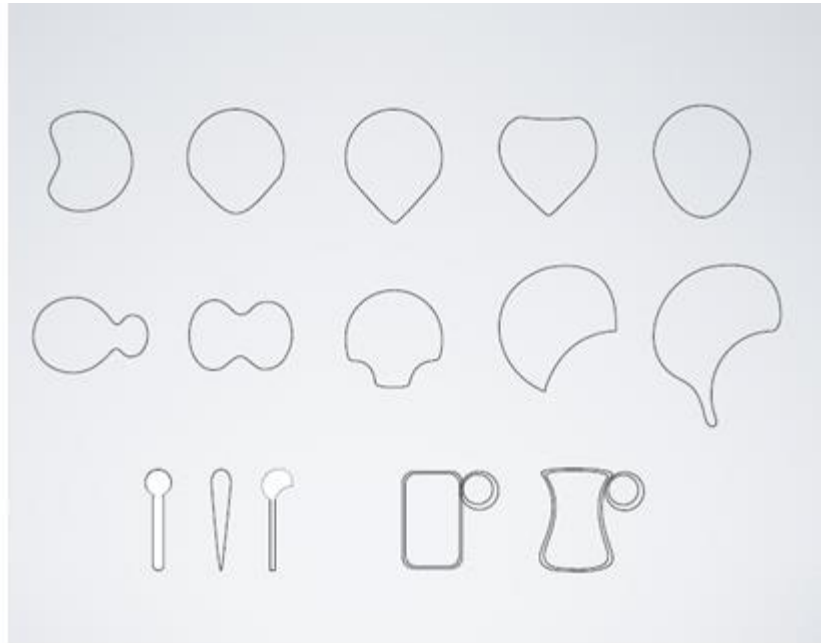


Figure 13: Form Exploration

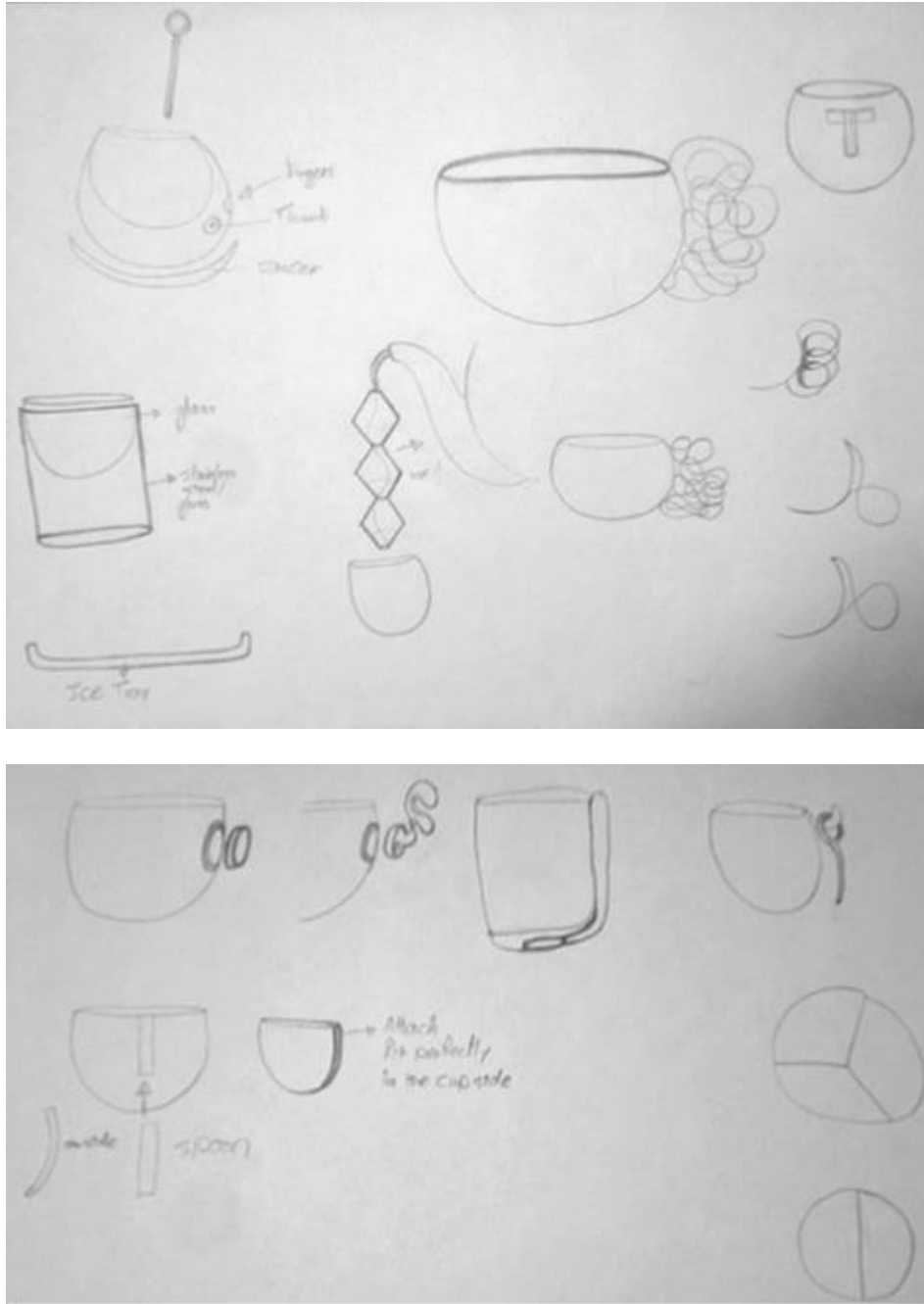


Figure 14: Cup, Saucer, and Teapot Sketches



Figure 17: 3D Modeling Design

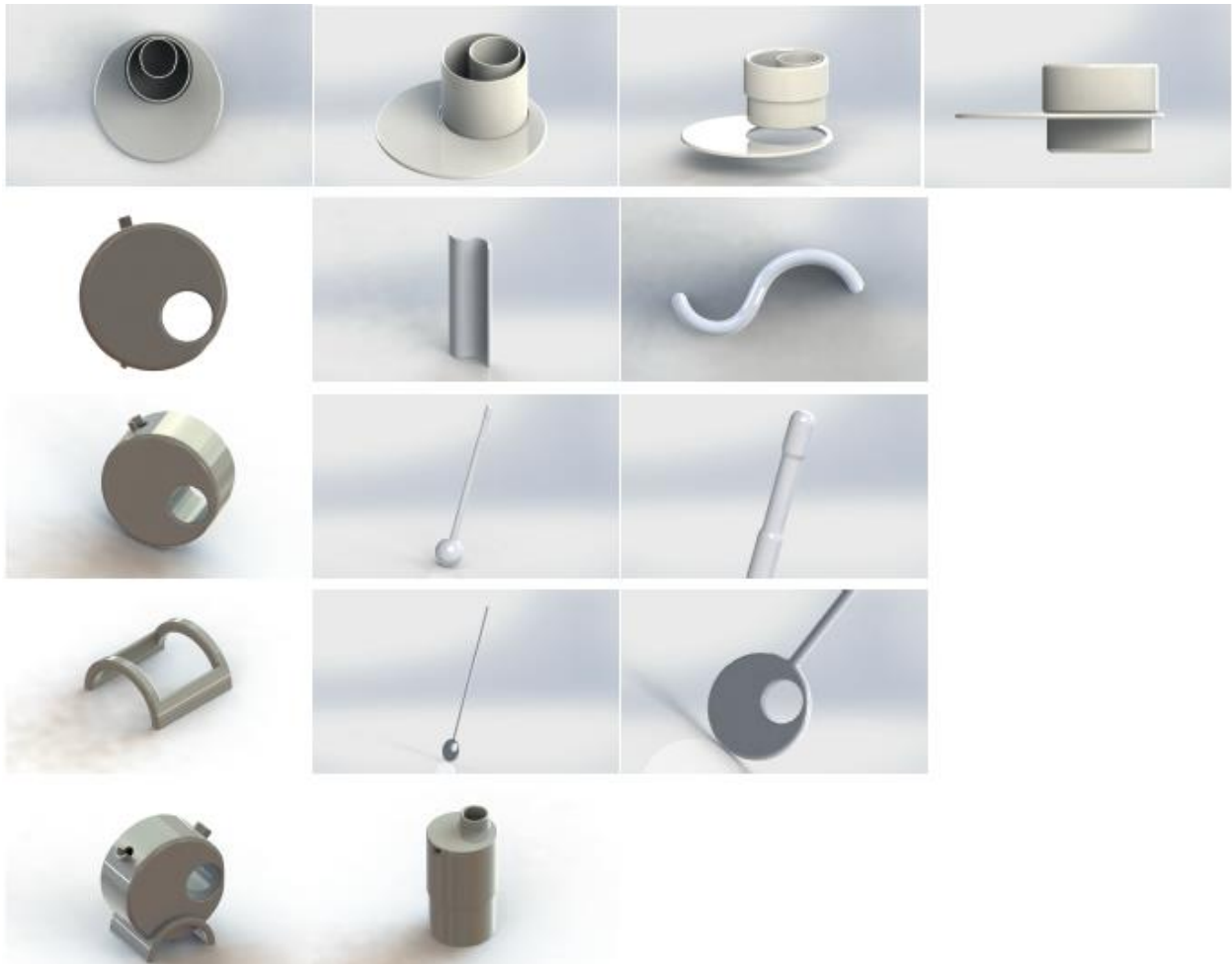


Figure 18: Design Mockups of Teacup, Water Pot, Stand, Saucer, and Spoon

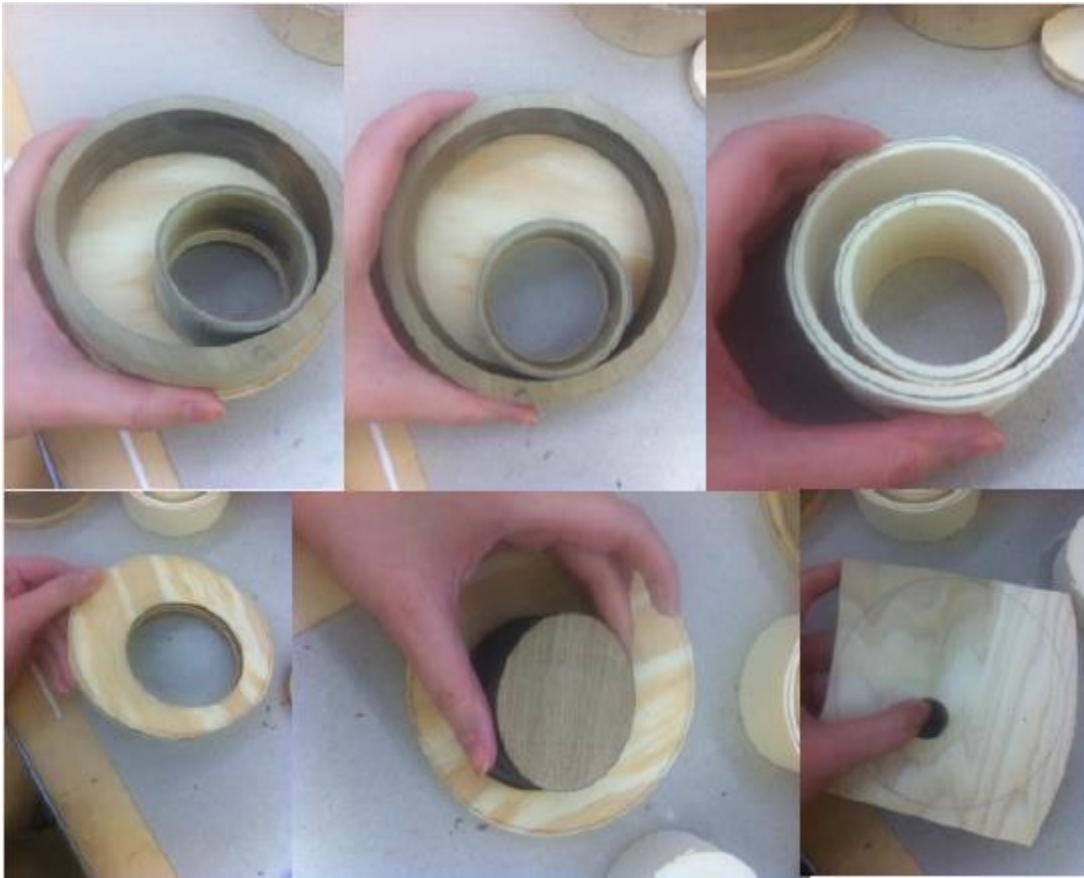


Figure 19: Design Mockups for Teacup

Manufacturing Process

Predecessors

Teapots and tea sets are one of the most traditional parts of everyday life. Though there have been changes in the design of the teapots, they have not much deviated from their core look. The reason being is because the function of the teapot is intrinsic to its design. Even the contemporary versions of the teapot in essence are still bonded



Figure 20: YiXing Teapot

with the traditional teapots in design.

The first remarkable teapots – the Yixing teapots are considered to be the best for brewing tea and for drinking from it directly as well. The YiXing teapots season gradually through use, as the unglazed clay absorbs the delicate flavor of the brewed tea. The YiXing teapots have greatly influenced the teapot designs the world over, and are also credited to the invention of porcelain in the West.

With the opening of the Japanese market, there was the advent of the Japanese form of pottery designs. The Japanese teapots were detailed with pictures of nature, their poems etc. YiXing pots too had such similar work done. The Japanese teapots were made from red clay.

The Asian influence on teapots can be seen in Figure 22; the teapots are typically decorated with delicate gold works or filigree. The European trends towards making teapots using hard paste porcelain. The European wares were known for their translucent look.



Figure 21: Japanese Ancient Teapot



Figure 22: European 16th and 17th Century Porcelain & Silver Teapots

In the 17th century England and France infused teapots with the Baroque and Rococo designs. But the shape of the teapot continued to be globular with some variations of pear shaped pots too. The 18th century saw the advent of silver and pewter teapots. This silver teapot with a leather handle is dated sometime in 1670s. After this, the Queen Anne and Georgian styles of teapots arrived. These are considered to be the most traditional of silver teapot designs.

The most common teapot, known as the Brown Betty teapot, was first introduced in the 19th Century. It was essentially made from English red clay and subsequently fired and glazed as to get it's unique finish. It is one of the best teapots when it comes to it's ability to retain heat, and was



Figure 23 : The Brown Betty

manufactured in Staffordshire, England. Other variations of the Brown Betty are teapots which are either glazed or unglazed, ceramic, or stoneware with stainless steel strainers.

In the 20th century the teapot design was influenced by the Art Deco Movement as can be seen in the image below.



Richard Notkin's Cube Skull Teapot



Steve Hansen's Man the Guns

Figure 24: The Art Deco Movement

Alteration

Christopher Dresser is a Scottish industrial designer, whose teapot designs were inspired by nature and his designs were the perfect balance of the simple and the complex, the predictable and the unpredictable and perfection and flaw. Dresser is considered as the pioneer of modern design.

Some of his designs showcased ornamental beauty, with streamlined utility. The designs were modern but at the same time not too simplistic, with gentle curves and no unnecessary angles. The Dresser teapot was designed spherically with a straight, no-nonsense ebony handle, and, a four legged stand, a small spout and another sphere on the top acting as the lid. Each of these elements fulfilled a specific function.

Design alterations for the teacup involved designs which would ensure that the teacup has an intrinsic cooling system. This cooling system was designed in such a way that the air flow is possible; this air flow, which occurs through the gap inside the cup, would assist in reducing the temperature of the tea without having to blow it. The thickness of the wall was good enough to retain the heat within the cup.

Another detail to pay attention to while designing the cup is that the cup is smooth from the inside. This is a good feature; if the inside of the cup is smooth and non-porous, the flavors of the tea would remain in the tea and do not get absorbed. The flavors would rise to the top of the cup, and the drinker can then enjoy the delicate fragrance of the tea, thus making the experience better. Similarly, the cup wall width at the opening has been designed in such a way that it is not too thick.

The teapot was inspired by Christopher Dresser teapot designs. That design, in line with Dresser's design, was planned to be steady and balanced even while pouring the tea. The handle

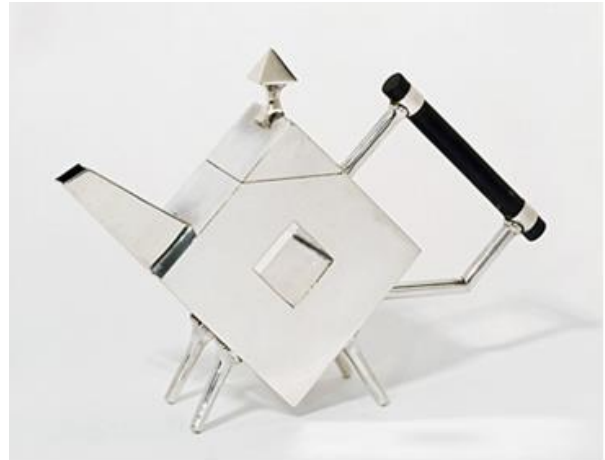
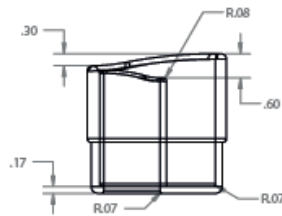
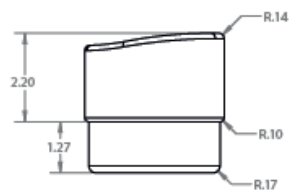
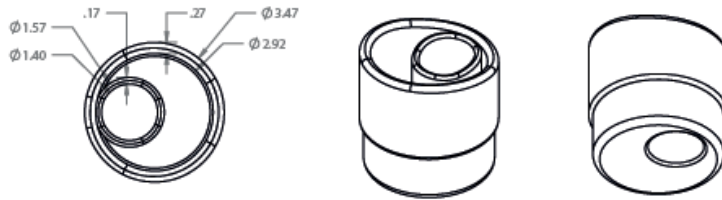


Figure 25: Christopher Dresser's Teapots

was designed in such a way that it should be comfortable to hold. The whole teapot was designed so that the center was perpendicular to the bottom and the handle.



Alteration
Teacup

Providing space for nose when drinking tea. Which is based on human factor.

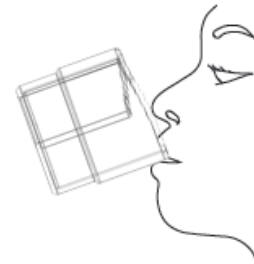
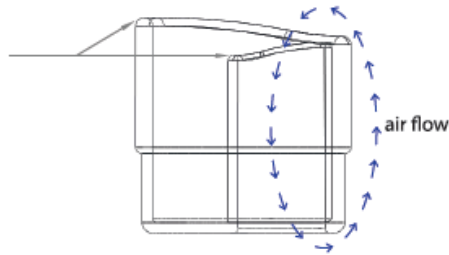
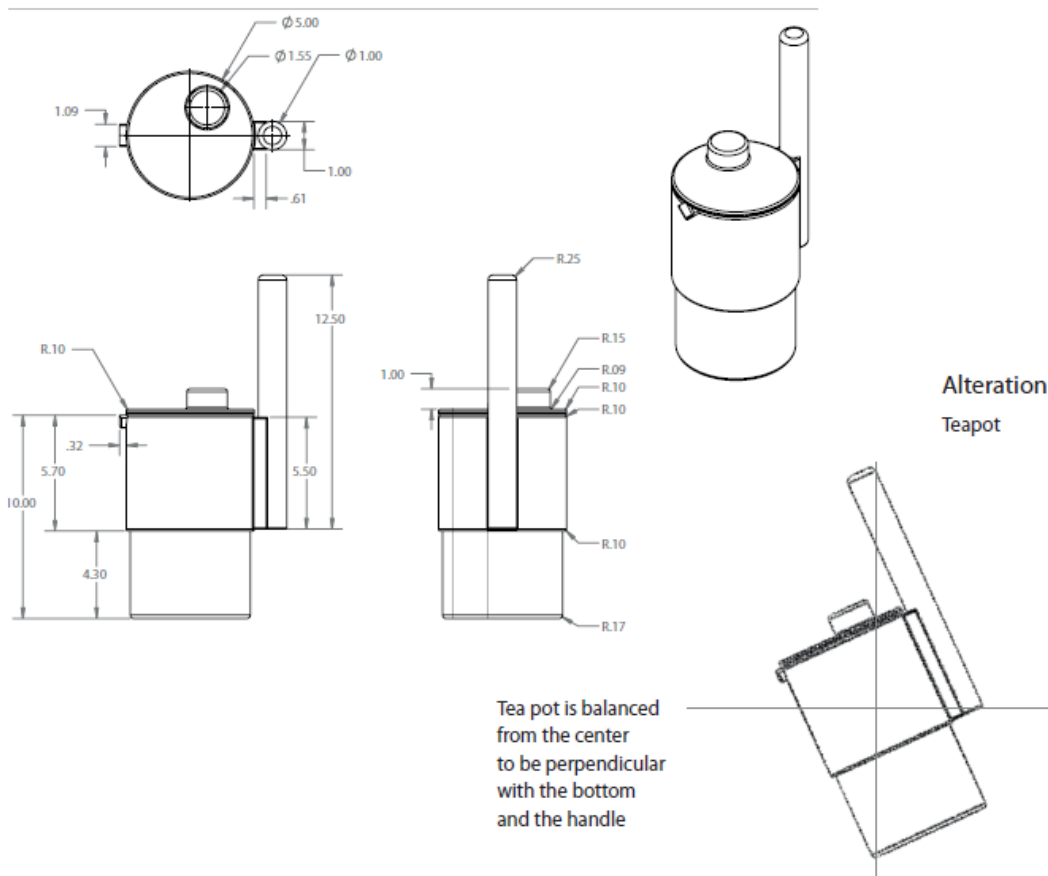


Figure 26: Teacup Alteration



Alteration
Teapot

Tea pot is balanced
from the center
to be perpendicular
with the bottom
and the handle

Figure 27: Teapot Alteration

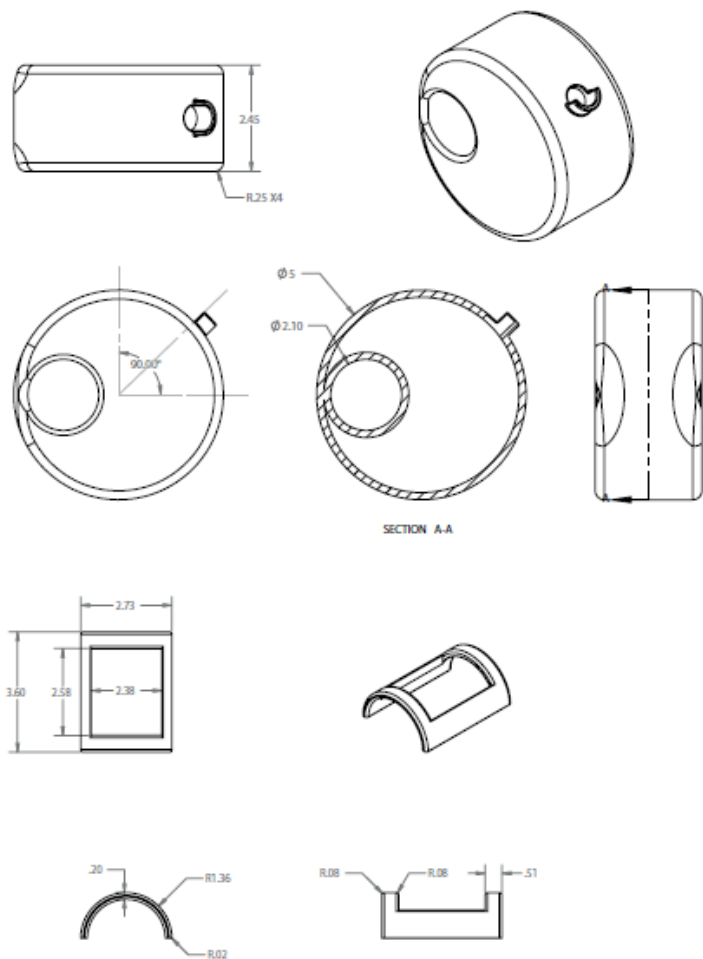


Figure 28: Water Pot and Stand

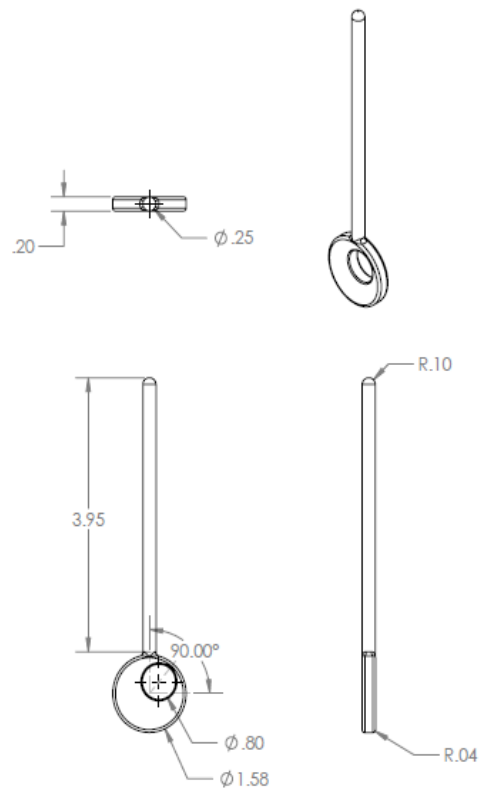


Figure 30: Tea Spoon Alteration

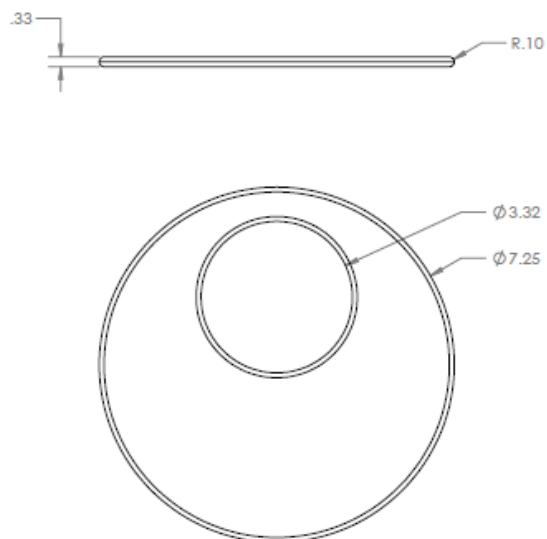


Figure 29: Tea Saucer Alteration



Figure 31: Tea Spoon Inspirations



Figure 32: Tea Spoon Concept 1



Figure 33: Tea Spoon Concept 2

Measurements

Based on measured volume, the water pot is designed to hold 2.5 cups from the final product, which is equivalent to approximately 300 ml. The wood handled teapot is meant to hold 9 cups of tea, which measures to 1150 ml. The teacup itself is capable of containing up to 130 ml of tea.

Tea set production methods

Wheel throwing technique was initially followed for making the teacups and the teapots. The wheel throwing technique was initially practiced in Mesopotamia, the Indus Valley and Central Asia in the 3rd Century AD (Childe, 1954). Wheel throwing is useful when mass production of handmade functional products is needed. The wheel head should be about 2 ft. to 2.5ft about the ground level. The wheel can be operated either by throwing left-handed or by right-handed throw.



Figure 34: Teacup Design Handmade



Figure 35: Tea Set Design Handmade



Figure 36: Teapot Design Handmade

Before throwing the clay on the wheel, it needs to be prepared well by kneading to a good consistency. The clay was wedged and a couple of balls of clay were made. Subsequently, the models were made after centering the clay, and by using the templates as a guide so that the desired shapes were obtained.

But this method was stopped after researching on the 3D printing techniques. This method ensures that the resulting products conform to the designs in totality. All the curves, dimensions etc. were absolutely in line with the designs, unlike in the case of the products resulting from wheel throwing or even casting.

Preparation/ Setup



Figure 37: Water Pot Design with Stand Homemade

For the wheel throwing technique which was initially followed, the following are the conditions for coming up with the tea set as per the design.

Clay	VC White Body Ingredients – XX sagger (10%), EPK 20, Grolleg 10, Talc 20, Wollastonite 10, Molochite 30, Bentonite 2%, Macaloid 2% 3124
Glaze	VC Satin Stone Ingredients: Frit3124 – 45%, Gerstly borate 10, Nepheline Sye 15, Talc 5, Flint 15, EPK 5
Temperature	1 st firing – Cone 08: 1650F 2 nd firing –Cone 04: 1960F

Table 2: Conditions for production

The figure 38 below provides the images at the different stages of the tea set design preparation.



Figure 38: The Making of the Tea Set

Production

Though the wheel throwing technique was initially followed, the production method chosen was the 3D Printing. The reason for choosing 3D Printing is as given below:

- 3D printing takes couple of hours alone. After designing the product, the design file needs to be sent to the printer without any need for manual intervention. The same can be built before the day ends. Thus reducing the time to market.
- Ability to make quick modifications without having to go in for prototypes.
- The cost for building prototypes is reduced drastically.

3D Printing, or additive manufacturing, is the process by which three dimensional objects can be created by using a digital model. Through additive processes, the product is produced by accurate positioning of the layers of material successively. Because of the use of 3D printing it is possible to combine different materials to identify the best material for producing the product. It is easy to produce the look and feel of glass, ceramic or metal along with the strength and temperature resistance factors [27].

For the production of the teapot, cup, spoon and the saucer computer modeling solution from SolidWorks would be used. SolidWorks [28] software provides a complete modeling environment for taking designs from concept to manufacturing. The process that is followed for the 3-D printing of the tea set is:

- The model would be drawn and the same is converted into the STL file format.
- The STL file of the model was sent to Shapeways, which is the 3D print company for 3D printing

The next step is to try selling the product and subsequently producing the products as per the customers' orders. In case there are any damages, the products can be replaced as needed through online request.

The MSDS Sheet

The following image is a sample of the MSDS sheet provided by the 3D printing organization Shapeways. The company's in-house MSDS sheet is below:

<u>MATERIAL SAFETY DATA SHEET</u>			
Product: Lead Free Gloss Glazes		PRODUCT CODE: LG Series - AP	

Manufacturer's Name: American Art Clay CO., Inc.			
Address: 6060 Guion Road			
Indianapolis, IN 46254			
Information Number: (800) 374-1600		Emergency Number: (800) 374-1600	

Section I - Product Identification			
Product Name: Gloss Glazes	Product Class: Ceramic Glazes	Product Size: 16 oz., 1 lb., gal	
LG 1, 10, 11, 14, 20, 21, 23, 24, 30, 32, 34, 36, 40, 42, 48, 50, 51, 52, 54, 55, 57, 58, 59, 60, 61, 62, 63, 65, 67, 68, 760, DC 10, TL-1, DW-11, Bennett Clear, Brickyard Clear Gloss Glaze and Class Packs			
Section II - Hazardous Ingredients			
Reportable Components	CAS#	Vapor Pressure Mm Hg @ Temp	Weight Percent
Water	7732-18-5		
Sodium Borosilicate Frit	65997-18-4		
Clay	1332-58-7		
Inorganic Stains	Mixture		
Gum	9004-32-4		
No reportable quantities of hazardous ingredients are present.			
No hazardous ingredients. This product carries the "AP" Seal. Labeling conforms to ASTM D4236.			
Section III - Physical / Chemical Characteristics			
Boiling Range: N/A	Specific Gravity (H2O=1): Less than 2		
Vapor Density: Heavier than air.	Evaporation Rate: N/A		
Coating V.O.C.: N/A	Material V.O.C.: N/A		
Appearance and Odor: Liquid / Dry			
Section IV - Fire and Explosion Hazards Data			
Flash Point: N/A	Method Used: N/A		
Flammable limits In Air by Volume: NA - Lower	NA - Upper:		
Extinguishing Media: N/A	Special Firefighting Procedures: No fire hazards.		
Unusual Fire and Explosion Hazards: None.			
Section V - Reactivity Data			
Stability: Stable	Conditions to Avoid: None		
Incompatibility (Materials to Avoid): None			
Hazardous Decomposition or Byproducts: Will not occur.			
Hazardous Polymerization: Will not occur.			

<u>MATERIAL SAFETY DATA SHEET</u>			
Product: Lead Free Gloss Glazes		PRODUCT CODE: LG Series - AP	

Manufacturer's Name: American Art Clay CO., Inc.			
Address: 6060 Guion Road			
Indianapolis, IN 46254			
Information Number: (800) 374-1600		Emergency Number: (800) 374-1600	

Section I - Product Identification			
Product Name: Gloss Glazes	Product Class: Ceramic Glazes	Product Size: 16 oz., 1 lb., gal	
LG 1, 10, 11, 14, 20, 21, 23, 24, 30, 32, 34, 36, 40, 42, 48, 50, 51, 52, 54, 55, 57, 58, 59, 60, 61, 62, 63, 65, 67, 68, 760, DC 10, TL-1, DW-11, Bennett Clear, Brickyard Clear Gloss Glaze and Class Packs			
Section II - Hazardous Ingredients			
Reportable Components	CAS#	Vapor Pressure Mm Hg @ Temp	Weight Percent
Water	7732-18-5		
Sodium Borosilicate Frit	65997-18-4		
Clay	1332-58-7		
Inorganic Stains	Mixture		
Gum	9004-32-4		
No reportable quantities of hazardous ingredients are present.			
No hazardous ingredients. This product carries the "AP" Seal. Labeling conforms to ASTM D4236.			
Section III - Physical / Chemical Characteristics			
Boiling Range: N/A	Specific Gravity (H2O=1): Less than 2		
Vapor Density: Heavier than air.	Evaporation Rate: N/A		
Coating V.O.C.: N/A	Material V.O.C.: N/A		
Appearance and Odor: Liquid / Dry			
Section IV - Fire and Explosion Hazards Data			
Flash Point: N/A	Method Used: N/A		
Flammable limits In Air by Volume: NA - Lower	NA - Upper:		
Extinguishing Media: N/A	Special Firefighting Procedures: No fire hazards.		
Unusual Fire and Explosion Hazards: None.			
Section V - Reactivity Data			
Stability: Stable	Conditions to Avoid: None		
Incompatibility (Materials to Avoid): None			
Hazardous Decomposition or Byproducts: Will not occur.			
Hazardous Polymerization: Will not occur.			



Figure 39: The Tea Set in Action



Figure 40: The Tea Set in Display at RIT in Rochester, NY

The customer response to the teapot and the teacups was done through participation in a design kiosk where the customer feedback was captured. The customers were very appreciative about the thought that had been put into the design, and they liked the design for its' simplicity and contemporary look.

During the display at Bevier Galery at Rochester Intitute of Technology (RIT) in March 19th 2013, a tea party was also held where prospective consumers were served Kuwaiti tea with traditional Kuwaiti desserts. This was done to demonstrate the functionality of the design, and the innovative integrated cooling system. Figure 41 below shows an image of the tea party and the customer response. An official invitation card was handed out for the tea party with details regarding the location, graduate thesis exhibition, and other contact information.



Figure 41: Customer Response



Figure 42: The Tea Set in Display at ICFF in New York City

The ICFF is an annual event held in the Jacob K. Javits Center located in New York City, May 21th 2013. The acronym ICFF stands for International Contemporary Furniture Fair, and the event is well renowned for its various contemporary designs that make their way into the market. The ICFF is home to some of the most innovative and uniquely designed products that hit the consumer market. The tea set was displayed at the 25th annual ICFF, where it was well received by a notable crowd of industry professionals as well as critics.

Discoveries and Innovations

The teapot and the teacups are designed in such a way that the lid of the teapot should be correctly placed and well-proportioned with an efficient flange. The spout and the handle placement, construction, and the proportion would be in such a way that the user can control the pouring of the tea and holding of the kettle without any discomfort. When it comes to the aesthetics of the tea set, the idea would be to keep it chic using white color and graceful lines.

The 3D printing technique helps in moving in this direction without having to spend too many resources, raw materials, and time. The modifications can be done without having too much time spent and the design innovations can be captured.

Conclusion

Industrial Uses

As has been mentioned earlier, there is a sizable demand for tea sets, and one that is only increasing. This tea set could certainly alter the traditional method of thinking by combining superior functionality with a high level of aesthetic appeal. Ideally, any potential company that is to be a suitor for the production of this tea set, would have to be one that has an understanding of the delicate balance between a product's functional and design appeal. Based on some research, I have



Figure 43: Future Plans – Stand for the cups

come across two spectrums when it comes to new products in the ceramic industry. First, there is

the traditional functionalist, who is strictly focused on function, and then, there is the ideal candidate for a product like my tea set, Jim Makins. “He is in an ever-vulnerable balance between idea (sculpture) and use, between philosophy and economy (Joris, 1987).” The potential producer or the company to appeal to would be Beach ware. Author Yvonne Joris (1987) discusses the three main groups that American ceramists, who are strongly involved with utility, fall into. These three groups are “the purists, the symbolists, and the stylists (Joris, 1987).” The idea with this tea set is to appeal to these three groups within the utility realm. This would ensure that that the first mover advantage is maximized by the purists and subsequently market penetration in the industry is maximized through the other two groups.

Future plans

Future plans for the tea set include the potential for mass production. As has been discussed in previous sections, there is a high and growing demand for tea consumption throughout the world. In combination with product appeal, innovativeness, and exclusivity in design, mass market success is highly likely. In order to accommodate mass production, the tea sets will likely use 3-dimensional or 3D printing. With today’s technology and



Figure 44: Future Plans – Package Design & Box

advancement in 3D printing, these printers are capable of accommodating anything from “one-offs to small batch production (Lefteri, 2008).” This allows for an experimental start, and then potential expansion for mass production, without the risk of having to endure high expenses due

to production methods from changing volume. 3D printing is also highly accommodating, and when it comes to designing it can adapt to simple designs as well as it can to highly complex designs. Because the teapot is a geometrically simple design, 3D printing will accommodate the design adequately.

Future Exploration

The plans for the future design steps for the tea set are to design the accessories for a stand, which could be used to hold the cups together. The design currently visualized for the teacup stand is as shown in figure 43.

The package of the tea set would be of acrylic; vacuum pressured and would be a white cardboard box as shown in the figure 44.

Some of the designs that are planned for the future to be incorporated on the teacup are shown in figure 44.

After successful design and production of the tea set, the next action item is to design coffee cups which, would meet the contemporary tastes of the people worldwide.

Pricing/Models

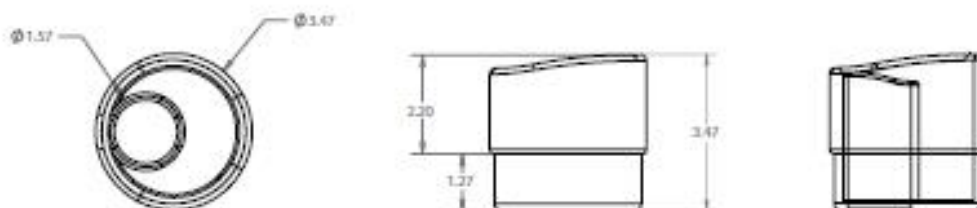
During the initial production run, the models will be available in two motifs, and these will be the White Ceramic glazed model with ancient Islamic black pattern all around on the cup surface, and the White Ceramic glazed model with black dots all around on the cup surface as shown in figure 45. These two motifs will distinguish the cup models. All models will be customizable based on customer specifications in regards to aesthetics and design requirements; however, the models' size and measurements are set to be retained on all produced products. The image below provides an accurate description of the initial pricing and model strategy.



Figure 45: Future Plans – Cup Designs/Motifs

Pricing / Models

Teacups



From 185- (All models customizable)

1. White Ceramic glazed
2. Motif Pattern on the cup surface

As shown \$185

White color ceramic glazed cup,
ancient Islamic black pattern all around on
the cup surface.

Starting \$175

White color ceramic glazed cup,
small black dots all around on the cup
surface.

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