

**An Investigation Into Transportable Coffee Mug
for UBC SUB Green Vending Machines**

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**AN INVESTIGATION INTO
TRANSPORTABLE COFFEE MUG
FOR UBC SUB
GREEN VENDING MACHINES**

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ABSTRACT

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The purpose of this report is to assess two types of coffee mugs made of stainless steel and porcelain based on the triple bottom line evaluation considering social, environmental and economical aspects. The stainless steel mug is produced by Thermos and porcelain mug is produced by DCI. The followings were discussed in the report: positive and negative sides of both products, a review on the history of the coffee mug materials and recommendations on the most sustainable choice of coffee mug based on the provided evidence.

The importance of using sustainable coffee mugs was discussed in the introduction section. In the next section, an explanation of the two types of coffee mugs chosen was provided and the chosen coffee mugs were assessed according to triple bottom line assessment. At the end of the report, the porcelain mug has been recommended as the more sustainable transportable coffee mug for the Green Vending Machines.

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GLOSSARY

Alloy:

A mixture or metallic solid solution composed of two or more elements

BPA:

It is an organic toxic compound with two phenol functional groups. It is used to make polycarbonate plastic and epoxy resins, along with other applications.

Chromium:

A chemical element with high corrosion resistance and hardness.

Chromium oxide:

It is the inorganic compound with chemical formula Cr_2O_3 . It is one of principal oxides of chromium and is used as a pigment.

CRES:

Corrosion-resistant steel

Kaolin:

Kaolinite is a clay mineral that has the chemical composition of $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$. The rocks that have large amounts of Kaolinite are called Kaolin or Clay China. (Wikipedia website, 2011;)

Passivation:

A process of making a material "passive", and thus less reactive with surrounding air, water, or other gases or liquids

Stainless steel:

A steel alloyed with at least 10 percent chromium in the metal mixture.

1.0 Introduction

Global warming and lack of energy resources are one of the new century issues, which have attracted a large amount of attention among public. The culture of the new century has been changed to embrace the idea of valuing future generations' rights of using the same sources that are currently being used. In order to achieve this, the concept of sustainable design, manufacture, and procedure should be understood. Sustainability is evaluated through considering the social, economical and environmental effects that a product, design, or procedure has. Rossner (2011) states that sustainability has started to be taken more seriously since 1980s.

To become a global leader in sustainability initiatives, University of British Columbia has put lots of effort into embracing new sustainable ideas and incorporating them into new projects on campus. The new Student Union Building (SUB) is one of the sustainable projects on campus to be finished in 2014. The new SUB will be a Leed Platinum building and sustainable design and operation is one of the most important features of this building.

As part of the sustainable operation of the SUB, so called "Green Vending Machines" will be placed in the building to provide sustainable food options to students, one of the products to be sold in these Machines is Transportable Coffee Mugs. In order to evaluate the sustainability of the potential transportable coffee mugs to be used in the future SUB, a triple bottom line assessment was conducted on two selected brands of coffee mugs: Thermos "Sipp™" and DCI "I Am Not A Paper Cup™" coffee mugs.



Figure 1: Thermos "Sipp™" coffee mug (Source: Thermos Product Catalog, 2011)



Figure 2: DCI "I Am Not A Paper Cup™" coffee mug (Source: DCI Products, 2011)

A triple bottom line assessment is defined as evaluating the social, environmental and economic aspects of a product. Upon looking at different types of coffee mugs available in the market, two brands of coffee mugs have been chosen out of which one brand is suggested as a more sustainable coffee mug brand based on the conducted triple bottom line assessment.

According to NCA [National Coffee Association of USA, 2009], 54% of overall adult population in US are coffee drinkers. In Canada, the coffee consumption has increased up to 10% during the past 20 years. The same increase rate is expected until 2020 [Agriculture and Agri-food Canada, 2011]. Based on this growing trend, an even higher demand of coffee mugs for the coffee drinker is predicted in the close future.

A coffee mug is usually used for drinking hot beverages. The available mugs in the market come in different shapes, sizes, colours, and materials. Therefore, a variety of options are available for a consumer to choose a coffee mug. The most common materials that are used to make coffee mugs include, stainless steel, porcelain, plastic and glass [Wikipedia, 2011]. Stainless steel and porcelain coffee mugs were chosen for this report based on their superior characteristics.

2.0 STAINLESS STEEL COFFEE MUG “SIPP™” BY THERMOS

One of the products that we have chosen for our report is Sipp™ by Thermos. It is made of stainless steel and has a capacity of 16 oz. This mug is constructed from double sided stainless steel body with leak-proof lid and has a built-in tea hook. Such design has an advanced insulation property, highly durable, non-toxic, and non-corrosive. Vacuum, which is between the double-sided stainless steel body, provides an excellent temperature preservation for both hot and cold beverages. The manufacture guarantees to preserve cold drinks for nine hours and hot beverages for six hours. The body of the traveler tumbler is built from indestructible stainless steel interior and exterior, according to Thermos. The mug is built from non-toxic and not corrosive materials. The unique characteristics of stainless steel will be discussed in a later section of the report. The leak-proof lid is made out of a BPA-free co-polyester called Eastman Tritan™. This co-polyester is resistant to stains, robust and non- toxic. The Sipp™ mug is dishwasher safe.

2.1 HISTORY OF STAINLESS STEEL DISCOVERY

Stainless steel was discovered in 1904. Leon Guillet published his research about an alloy, which composition was similar to today’s alloys known as 410, 420, 442, 446 and 440-C. Two years later he published his detailed research of an iron-nickel-chromium alloy. This alloy is a basis for metallurgical structure of modern stainless steel of 300 series. Later in England, in 1909 Leon Guillet produced a long description of the chrome-nickel stainless steel and published his studies on an alloy, which is known as a 430 stainless steel. Parallel to Guillet, two other scientists Monnatz and Borchers found evidence of steel resistance to corrosion, when the level of chromium in the steel and chromium mixture was at least 10.5 per cent [Wikipedia, 2011].

2.2 STAINLESS STEEL UNIQUE CHARACTERISTICS

Stainless steel high oxidation-resistance to any environment achieved due to an addition of chromium to the metal mixture. Stainless steel, also known as corrosion-resistant steel

(CRES), is used in applications that demand resistance to corrosion and property of steel. Stainless steel does not stain or rust. [Steel, J., 2006]. These great properties of stainless steel are due to a high concentration of chromium (Cr). In order for stainless steel to be resistive to oxidation it should contains at least 10.5% chromium by mass. A typical concentration of chromium in stainless steel is between 10.5 percent and 13 percent by weight. The above proportion is sufficient enough for most applications to prevent rusting. However, concentrations of chromium of up to 26 percent by weight are preferable for extreme corrosive environments [Specialty Steel Industry of North America, 2011]. Any amount of chromium from 10.5 percent to 26 percent creates a passive film of chromium oxide (Cr_2O_3) on the surface of the metal and prevents further oxidation of the steel. The invisible to the naked eye, chromium oxide layer always quickly forms on the surface of a freshly scratched up stainless steel. This unique process of metal protecting its surface is called passivation and could be observed in other metals such as aluminum or titanium [Wikipedia, 2011.]

2.3 TRIPLE BOTTOM LINE ASSESMENT FOR STAINLESS STEEL MUG

2.3.1 SOCIAL ASPECT

Stainless steel mugs are the most popular choice. This information was confirmed after speaking to the UBC bookstore sales manager and a convenient store sales manager located in the SUB. According to our interviews with the management staff, we found out that stainless steel mugs are definitely a more desirable choice, comparing to any other travelers coffee mugs. Stainless steel mugs are selling in the larger quantities. They are more attractive to buyers then any other coffee mugs or even more attractive than water bottles [Lee, D., 2008]. High reputation of stainless steel mugs is due their robustness and functionality. Stainless steel mugs are versatile and could last for a very long time.

All of the above features are implemented in the Thermos Sipp™. This coffee mug has a clean, attractive and functional design. It is double walled mug with an insulated lid, so that people can keep their favorite drinks at perfect temperature. Also, the coffee mug has a

spill-proof lid that can be opened with one hand. Such a handy feature prevents leakage and makes carrying the mug more convenient. The dishwasher safe feature is valuable and attractive to consumers, because it illuminates a necessity to hand-wash the mug. Also, this feature can potentially save energy, if the mug is washed in a dishwasher. It is proven that dishwashers are a better way to wash, then any hand washing. According to the University of Bonn, Germany, a typical dishwasher uses half the energy, less soap and only one-sixth of the water compare to hand washing. The University of Bonn studies are based on 4 to 6 gallon washing cycle [Burner, F., 2011]. Moreover, dishwashers eliminate the need to wash mugs by hands.

2.3.2 ENVIRONMENTAL ASPECT

To be sustainable, any materials have to meet certain criteria. The material has to provide relatively long overhaul life, therefore it most likely has to be robust, long -lasting, resist corrosion or any other atmospheric conditions. It should be recyclable to reduce use of earth resources. Stainless steel fits such conditions. Stainless steel is hundred percent recyclable. It does not lose its characteristics or qualities. Stainless steel has a high scrap value; therefore, it is not ending up at a dumping ground. Stainless steel mugs are BPA free.

During production of one kg of stainless steel an approximately 6.44 kg of CO₂ is released into atmosphere. The table below describes CO₂ production for common materials.

Common Material	CF (kgCO₂e per kg)
Aggregate, general	0.01
Aluminium, general	9.20
Brass, general	2.61
Bronze, general	4.41
Ceramics, general	0.69
Copper, general	3.22

Glass, general	0.90
Iron, general	2.08
Lead, general	1.41
Chromium	6.97
Cotton, padding	1.66
Cotton, fabric	8.77
Fibreglass (GRP)	8.87
Precious metal	6.69
General wool	0.19
Water	0.02
Paint, general	4.13
Paper and card, general	1.55
Plastics, general	3.09
Rubber, synthetic	4.39
Rubber, natural	1.78
Steel, general	1.91
Steel, stainless	6.44
Stone, general	0.06
Timber, general	0.47
Tin coated steel	2.10
Tin, general	14.52

Zinc, general	3.56
Food - plant-based	2.10
Food - animal-based	3.43

Table 1. Carbon conversion factors. (Source: LOCOG Guidelines , 2011)

As we can see, a production process of one kg of stainless steel pollutes ten times more than production of porcelain.

We conducted a little experiment where we weighted a several coffee mugs made out of porcelain and stainless steel. It turned out, that the weight of similar size stainless steel or porcelain mugs was almost identical. Their weight was approximately 350g. Based on the experiment, we could say that there is no significant difference in weight between stainless steel or porcelain tumblers. Therefore this experiment implies that a production of one stainless steel mug equal to a production of ten porcelain mug in terms of the CO₂ emission. So there is a big difference in carbon footprint during production of different type of mugs.

2.3.3 FINANCIAL ASPECT

At the beginning of the production, stainless steel traveler's mugs were expensive. However, these days, they have a comparable price to any other type of mugs. The cost of a typical stainless steel mug depends greatly on its size. Small stainless steel mugs are close in price to porcelain mugs, but medium or large stainless steel mugs are certainly more expensive than porcelain. A higher price of stainless steel mugs is definitely compensated by a better quality of the item that consumer gets.

There is a little variation on the price among porcelain mugs, glass mugs, plastic mugs or stainless steel mugs. This variation is on average between ten to fifteen dollars, depending on the manufacture. This relatively small price difference makes stainless steel mugs attractive to potential buyers.

3.0 PORCELAIN MUG “I Am Not A Paper Cup™” BY DECOR CRAFT INC

The second candidate among all the products we have chosen is “I Am Not A Paper Cup™” by DECOR CRAFT INC. (DCI). It is a double walled porcelain mug with a silicone lid, or usually known as a ceramic mug. The volume of it is approximately 300 ml.

The body of the mug is built with two layers of porcelain, so it can help hot liquids like coffee inside remain at their original temperature longer. Also, unlike common single wall ceramic mug, this double wall mug does not need a sleeve to prevent people’s hands from being burned. It can successfully preserve heat of the liquid inside and avoid the heat of the liquid to be transferred to the outer surface of the body. As a result, people do not need to be bothered by the fact that a ceramic mug has too many parts like sleeve which may be easily lost and hard to wash.

The lid that comes with the mug is made of silicone. This material has been greatly used in cookware because it is non-toxic, low-taint, and heat-resistant. Therefore, no toxic materials would be released even when it is in contact with hot coffee or tea.

The most amazing part of this product is that both the ceramic mug and the lid are dishwasher safe, and microwave safe [DCI, 2011].

3.1 HISTORY OF PORCELAIN MUG

Clay is a base ingredient of any pottery. The first use of pottery is recorded as around 6000BC. Originally pottery was used as a way to store produce such as grains or seeds [Yangshao, C., 2011]. Clay also is a base material of ceramic. Porcelain is one of the ceramic kinds. Three major kinds of porcelain include: hard-paste porcelain, soft-paste porcelain and bone china.

- Hard-paste porcelain is natural porcelain, also known as true porcelain, has been ideal model for porcelain producers. Chinese developed this type of porcelain from Kaolin and Petuntse. This type of porcelain has the greatest melting point compare to other type of porcelain, therefore the glaze and the body melts into one indistinguishable uniform form.
- Soft-paste porcelain has been developed in Europe and it is often called artificial porcelain. It was experimentally developed in effort to imitate hard-paste porcelain from China. Even though this type of porcelain originally was made to imitate hard-paste porcelain, it has an attractive creamy tone, which is preferable by some collectors.
- Bone china porcelain is made out of a mixture of Kaolin, Petuntse and bone ash. This combination of materials was discovered in England in 1750. The bone china is almost as hard as hard-paste porcelain. The bone ash additive increases the transparency of the porcelain [Wikipedia, 2011].

3.2 CHARACTERISTIC OF PORCELAIN MUGS

Ceramic is made from inorganic and nonmetallic materials that are prepared by exposing the raw materials to heat which is followed by cooling. The structure of ceramic materials can be various. It can be crystalline, partly crystalline, and amorphous. The most common ceramics used in the market have inorganic crystalline structure. One of the applications of ceramic materials is in pottery products. Whitewares is a ceramic type that is typically used in pottery products. According to Britannica Encyclopedia (2011), whitewares are characterized with their white to off-white appearance and depending on the raw materials used and the firing processes applied in their manufacture they have the following characteristics: impervious to fluids, low ability to react with other compounds, low electricity conductivity, and flexible in forming complex shapes. Porcelain is a type of whiteware that is used in pottery production industry. The main component of porcelain is clay in the form of kaolin which is categorized as a silicate mineral [Wikipedia, 2011].

3.3 TRIPLE BOTTOM LINE ASSESMENT FOR PORCELAIN MUG

3.3.1 FINANCIAL ASPECT

The price for single-wall ceramic mug is usually below \$10, but for the double walled porcelain mug, it is usually around \$15, which is still cheaper than common stainless steel mugs. However, the volume of this mug is only 300ml which compensates for its cheaper price. Moreover, by looking at the lifetime of this product, although it has a surprisingly long life time, a porcelain mug is fragile so it tends to break by the user's mistake.

Nevertheless, because we have chosen DCI as our recommended company, it is an American company which makes their mugs within the US. Thus, we can expect a lower shipping fee compared to those which have to be shipped from China.

3.3.2 ENVIRONMENT ASPECT

It has been a great issue that whether broken ceramic products can be recyclable or not, yet for most countries, ceramic products are viewed as general waste which means it is not recyclable. As ceramic products have been fired, it is fixed and can last forever. Although it is found in China that there are factories that do recycle ceramic products and make those broken products into new ceramic cookware or vases, the price for reusing the ceramic products are too high to have recycling ceramic products greatly popular, and this is the reason why broken ceramic products are still viewed as general waste for most countries today. Nevertheless, there are still ways to make use of broken ceramic products. For example, people can make mosaic project such as a mosaic picture frame or use them in the garden. In brief, compared to stainless steel, porcelain has lower environmental value.

According to Amazon.com website, the weight of the cup is one pound. The carbon emission for each kg of ceramic in general is 0.69 kg CO₂ for 1 kg of ceramic. The estimated amount of

carbon emission for producing the DCI cup is as follows: $0.69 \text{ kg CO}_2/\text{kg ceramic} * 0.453 \text{ kg Ceramic} = 0.313 \text{ kg CO}_2$. Thus, because ceramic mug has a much lower greenhouse gas emission, it is still a good candidate to be UBC's transportable mug.

Furthermore, one of the good advantages of choosing DCI's products is that they ship their products from the US just like the above section mentioned. We can also expect a lower greenhouse gas emission during the products' transportation.

3.3.3 SOCIAL ASPECT

The purpose of this project is to promote students and staffs in UBC to use a transportable coffee mug instead of using paper cups provided by coffee shops in order to reduce the waste due to disposal of these paper coffee cups and the plastic lids. In addition, UBC viewed as a leading role model of promoting sustainability among all North American universities is setting its goal to let every student and staff of UBC to be more aware of sustainability, and be sustainable themselves. As a result, a transportable coffee mug is an excellent idea to let people be sustainable and also remind people of being sustainable when they are using the mugs. DCI's ceramic mug is a good option because it is cheap and it is light and handy for people on the campus to carry around, and a variety of colors of the mug is available for people to choose in order to promote the sales, which can be seen as the most important goal as we hope to have as many people to use this environmental friendly mugs as we can. Furthermore, this mug is easy to clean because it only contains the mug itself and a lid, and it is even dishwasher safe. Nevertheless, DCI's mug chooses silicone as the material of its lid; although this material is non-toxic and heat resistant, it is flexible and might cause coffee or liquids inside to leak or spill if the lid is opened due to external force by mistake. In short, DCI's ceramic mug is still a perfect choice for this project despite these little disadvantages; however, comparing to Thermos stainless steel mug, they do not have the same amount of sales, and are not attractive to the consumers as much as stainless steel mug.

4.0 Conclusion

The market for a coffee mug is surprisingly large, and the choice for customers seems limitless. It is impossible to choose *the best* coffee mug; however, based on the triple-bottom line analysis using the indicators we have chosen, we conclude one is better than the other.

We have closely evaluated a stainless steel mug from Thermos, which is arguably the largest company in the coffee mug industry, and a ceramic mug from DCI, which is valued for its creative designs and functionality. As a result of the evaluation in economic, environmental, and social aspect, we conclude that the ceramic mug from DCI has more superior qualities. Despite the customers' preference towards stainless steel mugs, the ceramic mug is a better choice for the Green Vending Machine in the new Student Union Building.

It is clear that Thermos' stainless mug is more expensive. The retail prices of the stainless mug and the ceramic mug are \$30 and \$20, respectively. The Thermos mug costs 50% more than the one from DCI. In addition, the carbon emission, in general, from a stainless steel is approximately 10 times greater than that from a ceramic mug. Although stainless mugs have these negative aspects, they are still the best-sellers in the market. Therefore, we strongly recommend that the DCI ceramic mug be promoted as an iconic symbol of a sustainable coffee mug.

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