Perfume Bracelet

Design Concept by Oliver Thompson

Contents

Abstract

Modern society faces a packaging crisis. It is a designer's job to responsibly create effective and environmentally friendly packaging solutions designed for a circular rather than a linear economy; in order to begin to repair the damage of decades of irresponsible design.

1. Landfill emits toxins and greenhouse gases

2. The 'Russian doll' effect; packaging within packaging

3. Designing for disassembly makes recycling easier

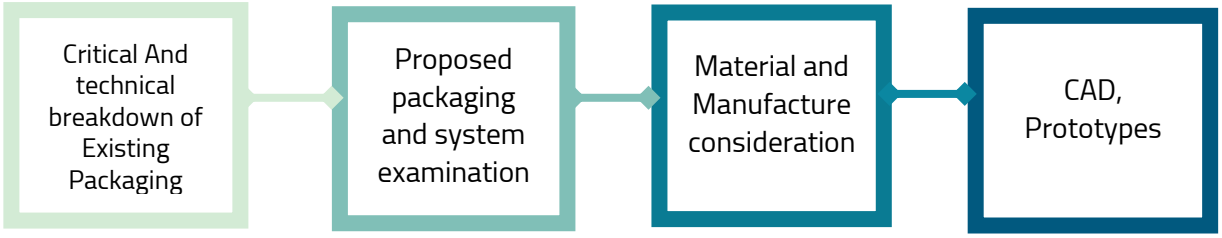
Perfume is an unusual product with respect to its packaging. The cosmetics industry attaches huge importance to how packaging looks and feels as often the product itself (e.g. face cream or moisturiser) has no visual appeal in its own right.

The covering box is designed to be disposed of immediately, and as such is typically made of cheaper materials. By contrast the bottle itself is expected to be on display in the user's home until it is empty, and this presents important opportunities for branding. The structure and design of both the bottle and the covering box is used to appeal to the specific target user group and may convey the compositional component of the perfume non-verbally, for example jasmine scented perfume may be sold in a bottle resembling a jasmine flower. It is often easy to tell who the perfume was designed for simply by looking at the bottle. Most other packaging desirables take a back seat to this criterion and few perfume bottles are designed with any consideration given to eventual disposal, reuse or recyclability. They are often deliberately designed to prevent reuse to maximise profits and prevent the user refilling a bottle with a different perfume. It is unacceptable and irresponsible to design such attractive packages and yet omit any consideration to its end of life cycle.

Other packaging requirements must consider the safety concerns of products containing flammable, irritable liquid both during transit and in a domestic environment e.g. child proofing. In addition to this it is important to convey product information externally.

I propose a comprehensive redesign of the system by which perfume is distributed, packaged and used, without sacrificing any of the existing desirables or function of current perfume bottles.

Design Process



1. https://www.packagingnews.co.uk/news/environment/esa-calls-chancellor-tackle-irresponsible-packaging-20-11-2017
2. https://nhlifefree.com/2017/11/21/amazon-packaging-is-socially-irresponsible/
3. https://blog.unifiedmanufacturing.com/bad-packaging-designs-ruin-products/

Introduction

The Brief

The task was to redesign a packaging product, either one we had been given or one we chose ourselves. I was given an empty bottle of Estee Lauder Youth Dew eau de parfum and immediately felt that this packaging had huge scope for improvement. My job is to identify unsustainable aspects of the product-service system, product lifecycle model, manufacturing processes, materials and the product itself. I will use this information to propose a brand-new design for a packaging product delivering the expected functions and outcomes of packaging, while also improving its sustainability footprint.

The perfume bottle I was given is marketed towards older women. Not wanting to restrict my design I've chosen to keep my branding and target market group options open. The purpose of the project is to demonstrate the new packaging and the accompanying system rather than to design jewellery. The minutiae of marketing the product for a specific target market is beyond the scope of this report as the system can be adapted for a large variety of user groups.

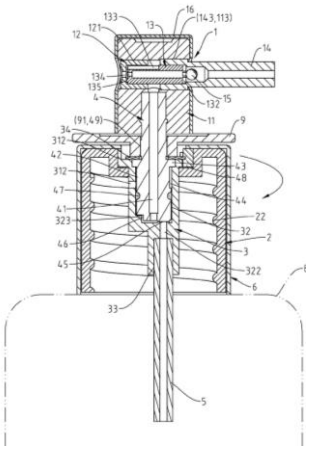
Whilst the word perfume is sometimes erroneously assumed to be gender specific to women, (the word denotes scent concentration) this product is designed for both genders. In reality it is expected that the product would have more appeal for women as they make up the majority of perfume and jewellery customers.

Existing Product Mood Board

I developed a mood board of various designs of perfume bottles that interested me. From here it is easy to see the wide variety of design style across the different user groups, and hence the importance of the bottles aesthetic.

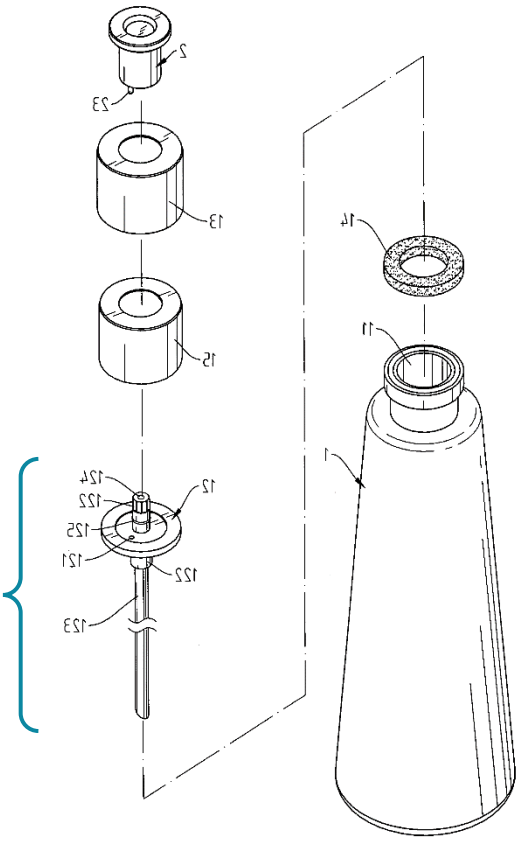
Existing Packaging Analysis

Perfumes are packaged depending on their composition: Alcohol and some oil-based perfumes are sold in bottles with either an atomiser mechanism or an open cap. In some rare cases wax-based perfume is sold in a jar-style container due to its viscosity. Given their prevalence in the industry I will holistically and critically examine the typical perfume bottle below and identify some of the design flaws and sustainability issues.



- Multiple Parts
- Multiple Materials
- Crimped Assembly

1. Atomizer cross sectional view



- Long Plastic Tube
- Anodized Aluminium

2. Perfume bottle exploded view

Glass

The moulded glass bottles usually range in capacity between 25ml and 200ml. The bottle is often deceptively designed with thicker glass to give the illusion of a larger capacity, and often conveys style, compositional components of the contents and target user group through a meticulous design: Some perfume bottles are works of art. Their primary purposes are aesthetics and branding, physical protection (preventing breakages and spills) and ergonomics.

Glass is chosen due to its premium physical material experience properties and its ability to maintain high structural integrity against the corrosive properties of some perfumes. The physical integrity of the bottle is extremely important as not only are there some import and export restrictions on flammable liquids, but spilt perfume could present a hazard in a household environment.

Glass is difficult to recycle. It must be separated by colour and washed before it can be processed, but it does not degrade over the recycling procedure and can therefore be used again and again.

Unfortunately, this glass bottle cannot be readily recycled as perfume bottles are assembled by crimping; a production method which is not designed to be undone. Whilst this is partially to ensure a tight seal for the aforementioned reasons, the reality is to prevent customers from refilling the bottle with another brand of perfume. A decision made at the expense of the packaging's recyclability.

1. US Patent US8167178 B2
2. US Patent US8167178 B1

Plastic

The atomiser mechanism is constructed from 5 or 6 polypropylene (PP) components and a steel spring assembled using snap and interference fits. PP is used due to its availability and corrosion resistance. It is the most common plastic waste, and whilst it can be recycled after being washed and sorted it remains one of the least recycled consumer plastics.

Due to the assembly techniques used the spring is extremely difficult to remove from the PP and would require specialist tools (I needed pliers and a knife to separate them). This effectively prevents the plastic components from being recycled.

Anodised Aluminium

Anodising metal can provide a coating with enhanced functional and visual properties. It is common for cheaper metals to be used in the lid and crimped bottle neck and coating gives a more premium look. The anodising process as outlined below creates harmful toxins that can be extremely damaging to the environment.

Anodising metal does not affect its recyclability and hence its inclusion in the packaging is one of the less questionable material decisions providing the by-products are disposed of correctly.

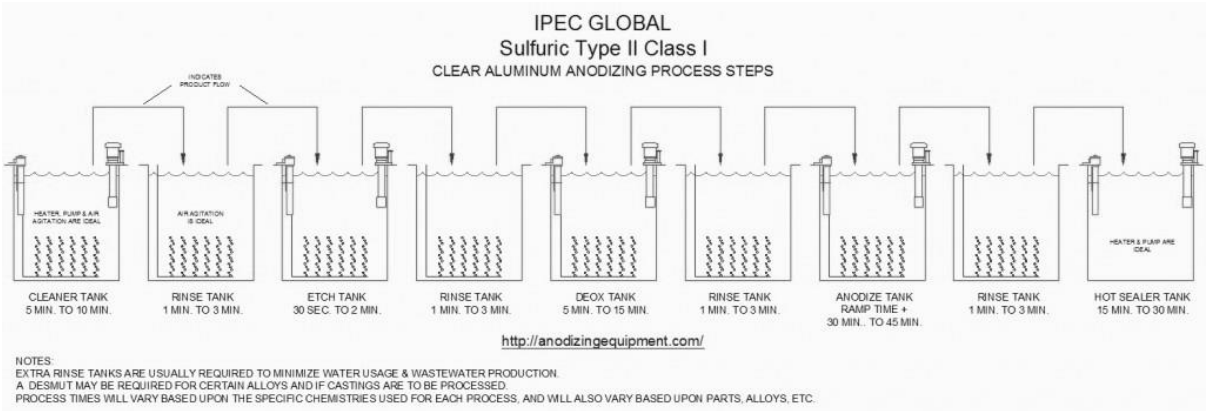
1.Sorting PP by hand

Other Materials

Nitrile rubber, spring steel, embossed card and carboard are also found in this packaging bringing the material count up to 7. As a rule of thumb packaging should use the fewest types of material to make manufacture and disposal cheaper and more sustainable.

Conclusion

The materials used in this product are mostly recyclable in their own right. The failure to design for disassembly however has nullified these benefits leaving a product that can only be disposed of in a landfill sight, where it will fully decay after several millennia.



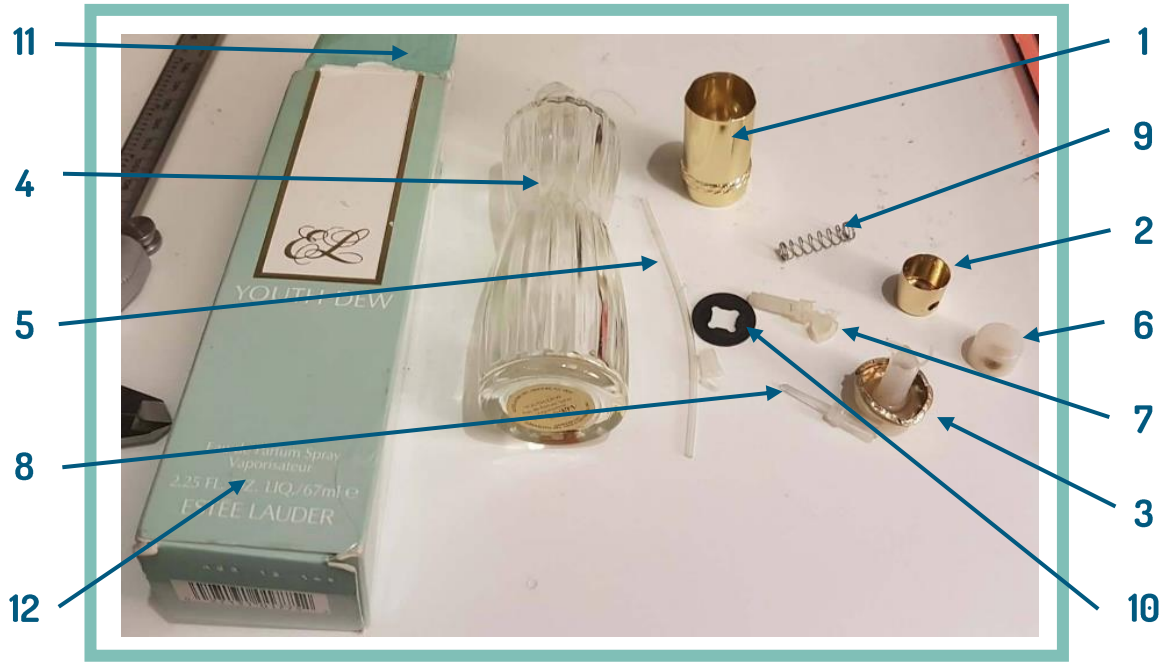
2. Aluminium Anodising Process

1. https://www.thebalance.com/plastic-recycling-facts-and-figures-2877886
2. http://anodizingequipment.com/anodizing-tips-and-tricks/how-to-anodize-aluminum/

Technical Breakdown

The packaging I chose to analyse was from the Estée Lauder Youth Dew. It is very typical of a high-end perfume, and has been on the market for many decades. Estée Lauder is one of the 7 main competitors on the cosmetics industry alongside Procter & Gamble, L'Oréal, Unilever, Avon, Beiersdorf and Shiseido. This is the type of company I kept in mind when designing the new product system.

The packaging was disassembled into its constituent components using pliers and knives. Close attention was paid to the manufacturing processes and materials found in the packaging. I categorised these components and conducted a technical analysis in order to gain further insight into the problem I aim to solve.



	Component 1	Component 2	Component 3	Component 4	Component 5	Component 6	Component 7	Component 8	Component 9
Material type	Anodised Aluminium	Anodised Aluminium	Anodised Aluminium	Glass	Polypropylene	Polypropylene	Polypropylene	Polypropylene	Spring
Material origin	Virgin mined bauxite	Virgin mined bauxite	Virgin mined bauxite	Virgin mined silica sand	Virgin crude oil	Virgin crude oil	Virgin crude oil	Virgin crude oil	Virgin Spring Steel
Dimensions (mm)	13.61 x 14.22	39.42 x 22.69	20.88 x 11.25	121.93 x 41.12	7.55 x 9.65	13.71 x 9.55	6.26 x 31.23	2.02 x 98.96	24.50 x 6.29
Weight (gr)	0.6	2.6	1.9	104.9	<0.1	0.6	0.2	<0.1	0.3
Shape	Hollow cylinder open at one end.	Hollow cylinder open at one end and 4.18mm diameter circular hole.	Hollow stepped cylinder with crimped edges.	Cylinder with conical taper.	Hollow Stepped Cylinder	Cylinder with small atomizer nozzle hole.	Pin	Flexible Tube	Compression Spring
Count	1	1	1	1	1	1	1	1	1
Manufacturing process	Deep Drawn and coated.	Deep Drawn and coated.	Deep Drawn and coated.	Blow Molded	Injection Molded	Injection Molded	Injection Molded	Injection Molded	Coiling
Fastener/Joining method	Inteference fit	Inteference fit	Crimped	Crimped around glass lip	Adhesive	Inteference fit	Inteference Fit	Inteference Fit	Compression fit
Disassembly mechanism	Force	Twisting	Folding back the crimped edges	Removal from crimped aluminium	Force	Force	Force	Force	Force
Tool required for disassembly	Hand	Hand	Pliers	Pliers	Pliers	Hand	Pliers	Hand	Hand
End of life	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle

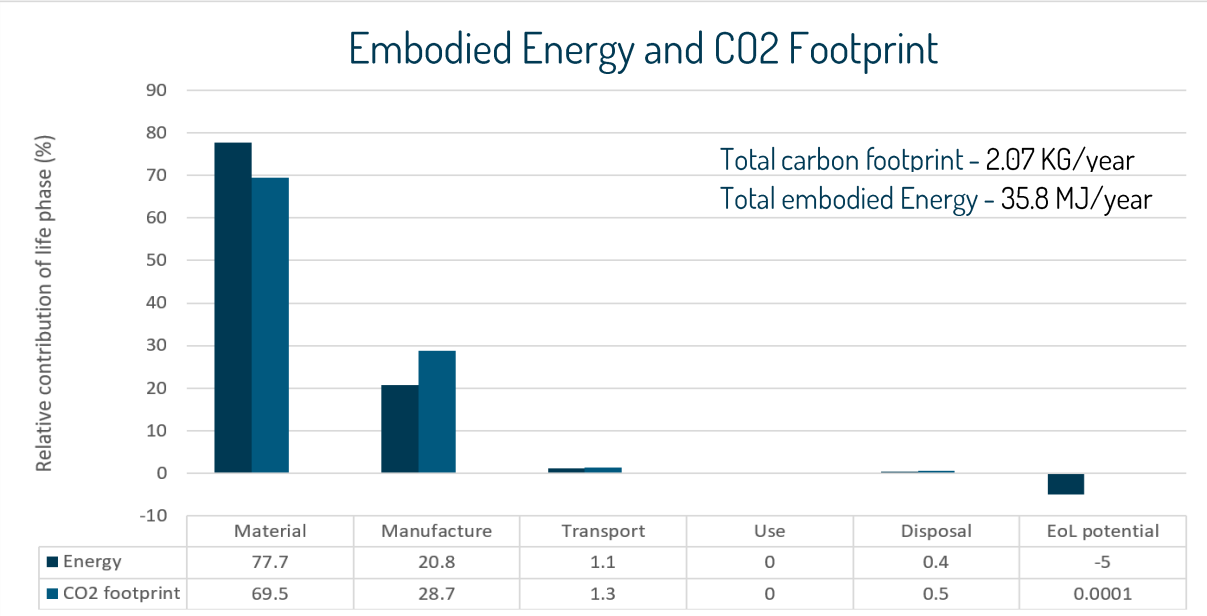
Table continued on next page

	Component 10	Component 11	Component 12
Material type	Rubber	Embossed Card	Cardboard
Material origin	Virgin Natural	Virgin Natural wood pulp and aqueous gloss coating	Virgin Natural wood pulp
Dimensions (mm)	19.61 x 0.95	49.33 x 49.32 x 155.76	48.43 x 48.42 x 155.4
Weight (gr)	0.2	17.2	3.6
Shape	Washer Shape with square internal hole	Folded oblong	Folded oblong insert with open ends.
Count	1	1	
Manufacturing process	Press formed	Stamped, coated with aqueous solution and folded	Perforated and folded
Fastener/Joining method	Sandwiched between glass and aluminium components.	Adhesive	Inteference fit
Disassembly mechanism	Lifting	Cutting	Removal from Card box
Tool required for disassembly	Hand	Scissors	Hand
End of life	Landfill	Recycle	Recycle

Eco Analysis & Conclusion

A full eco audit was conducted on each of the components, and their respective manufacturing techniques and materials. With the help of CES Edupak the carbon footprint and embodied energy of the product as a whole was found.

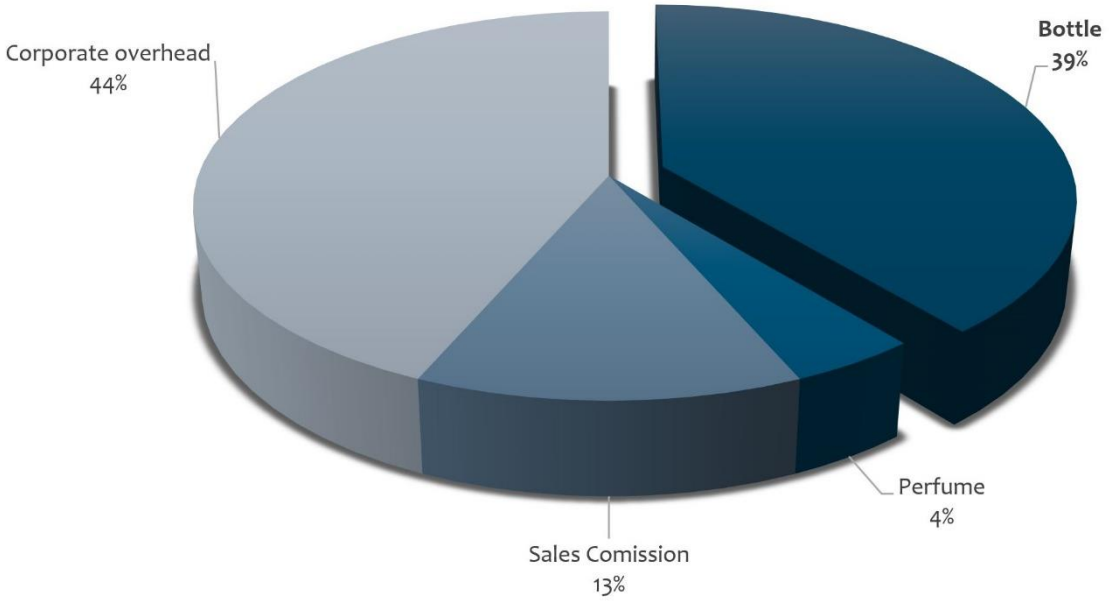
This data served as a benchmark by which I could begin to improve the packaging system. The technical metrics allow me to better understand exactly which materials and manufacturing techniques need to be replaced. The materials themselves proved to have the largest environmental impact with glass being the worst offender of the 7 materials. This figure would be significantly lower if the glass came from renewable sources or was recycled at its end of life.



Component	Material	Recycled content* (%)	Part mass (kg)	Qty.	Total mass (kg)	Energy (MJ)	%
Lid	Aluminium alloys	Virgin (0%)	0.0006	1	0.0006	0.12	1.8
Nozzle Cover	Aluminium alloys	Virgin (0%)	0.0026	1	0.0026	0.54	7.8
Cap	Aluminium alloys	Virgin (0%)	0.0019	1	0.0019	0.4	5.7
Spring	Medium carbon steel	Virgin (0%)	0.0003	1	0.0003	0.0079	0.1
Seal	Natural rubber (NR)	Virgin (0%)	0.0002	1	0.0002	0.014	0.2
Atomiser Assembly	Polypropylene (PP)	Virgin (0%)	0.009	1	0.009	0.72	10.3
Outer Packaging	Paper and cardboard	Virgin (0%)	0.021	1	0.021	1.1	15.4
Glass	Silica glass	Virgin (0%)	0.1	1	0.1	4.1	58.8
Total				**8**	**0.14**	**7**	**100**

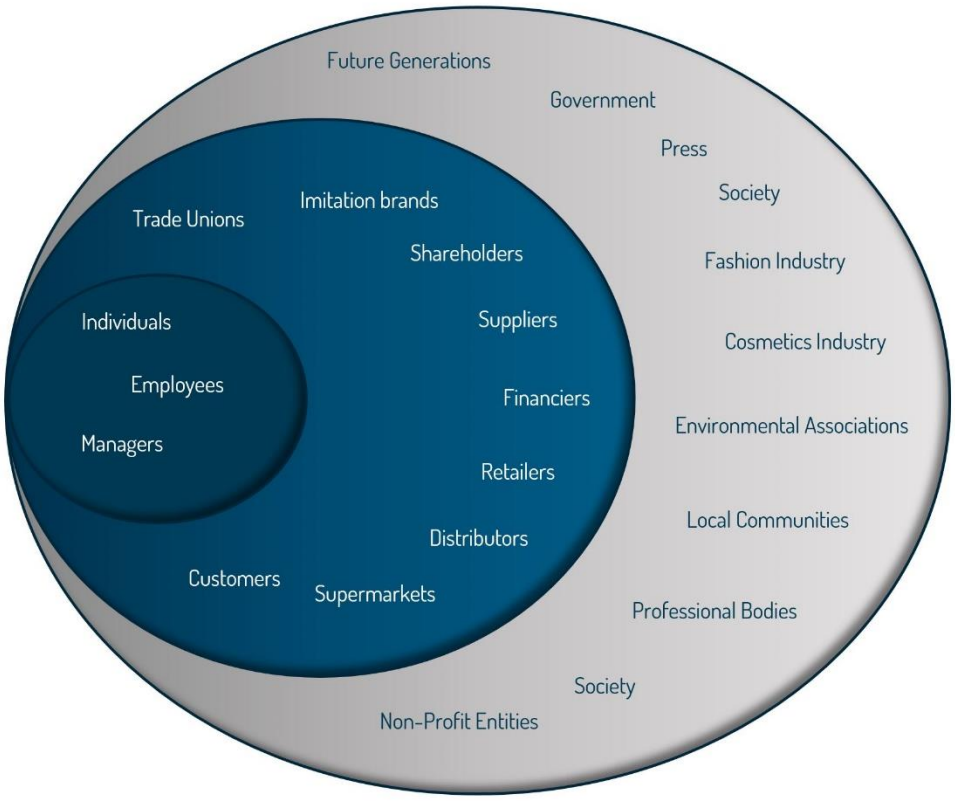
1. Table of embodied energy for different components

Cost Breakdown



1. Chart to show breakdown of the retail cost of a bottle of perfume. Note how much more money is spent on the bottle than the perfume.

Stakeholders Map



1. This map shows the key stakeholders who influence the project

Ellen Macarthur Economy Model

Ellen Macarthur Foundation

The Ellen Macarthur foundation aims to repurpose the traditional linear life cycle of materials (i.e. virgin manufacture to landfill) with 3 main objectives: Designing out waste and pollution, keeping products and materials in use and regenerating natural systems.

Existing perfume bottles fly in the face of this philosophy as they are designed with virgin materials, not reused and non-recyclable. Designing for a circular economy can be used to improve the quality of products by upgrading disposable packaging to a product designed for extended use.

Perfume Packaging Desirables

Survey

A survey of 25 people was conducted to further understand what people most wanted from their perfume bottles, with each criterion rated out of 5. The summation of each choice is displayed on the chart to the right. The participants were chosen to vary age and gender.

The results disagree with what one might expect when examining perfume packaging. Capacity proved to be a main concern but perfume bottles rarely contain more than 100ml to facilitate more frequent replacement. Ergonomics and Aesthetic fall in line with expectations but both branding and ingredients fell short and were less influential than expected.

1. Packaging Desirables Survey Data

User Personas

Christopher

Christopher works in the high-flying world of city finance. He prides himself on his professional appearance and will use a splash of cologne before he leaves for work. Christopher travels abroad regularly in a professional capacity carrying only hand luggage. On his recent trip to Milan he reached into his briefcase to discover that his small bottle of cologne had shattered, and caused all his belongings to smell strongly of perfume. Since then Christopher has to open up his cologne using pliers to transfer it to a stronger bottle to ensure it will survive the journey.

Klara

Klara is a fashion designer for a small family run business in Germany. She is a proud advocate of animal welfare and feels strongly about the environment. She only uses organic products in her home, avoiding the use of harsh domestic chemicals. Klara rarely uses perfume as alcohol irritates her skin and causes her to come out in a rash, and she wishes more alcohol-free perfume was readily available lives both locally and online.

Layla

Layla is studying economics at Edinburgh university and enjoys nights out at clubs or bars with her friends. She has a personal goal of going out once a week so she doesn't get consumed by all her coursework. She wears perfume on a day to day basis, but will occasionally forget to apply it. Layla also loves to wear jewellery but finds it difficult to afford on her student loan. After a busy day she finds that the perfume she put on in the morning has lost its potency and she must reapply it should she wish to go out in the evening.

1. https://www.shutterstock.com/video/clip-13200098-stock-footage-african-american-man-using-business-app-on-
2. http://lablogbeaute.co.uk/index.php/2016/06/14/health-wise-what-changes-as-we-age/
3. https://www.istockphoto.com/gb/photos/young-women

Product Design Specification

Criteria	Importance	Explanation
Aesthetics	Essential	The bracelet must be attractive to a wide target market group. Iit must suit different colours, styles of clothing and look attractive against different skin tones.
Colour	Ideal	The colour must adhere to the existing styling of the brand's. There are no strict criteria, but a designer brand would be unlikely to sell neon orange jewellery for example.
Cost	Ideal	The Bracelet must not be more than £23. The sachets should not exceed £2.50 each. The cost will be smaller if the subscription purchase system is used.
Documentation	Essential	The second stage packaging should have comprehensive instructions for the user to follow. Ideally there would be no requirement for a separate instruction booklet.
Durability	Essential	The bracelet would have to withstand general wear and tear encountered on a night out. The sachet would need to survive any impact that it may receive during the shipping process.
Environment	Essential	The bracelet must use considerably less energy than the existing packaging solution. It must also have a lower carbon footprint. The perfume sachets and other packaging should be recyclable.
Health and Safety	Essential	The perfume must be inflammable, non-toxic and safe to use against the skin. The bracelet must be loose enough to wear comfortably and have no sharp edges.
Language	Ideal	The packaging must be printed with the appropriate language for its retail location. Different packaging would be distributed to different locations around the world.
Length	Ideal	The bracelet must be long enough to fit around wrists of different sizes and genders. It should be easy to remove links in order to adjust length.
Lifetime	Essential	The bracelet must be designed for an extended lifespan. The sachets should be designed to be recycled upon use.
Location	Ideal	The product can be sold all over the world. The product service system and packaging must be appropriate for all global markets.
Manufacture	Essential	The packaging must be mass produced sustainably and consistently. Low energy methods of manufacture should be adopted.

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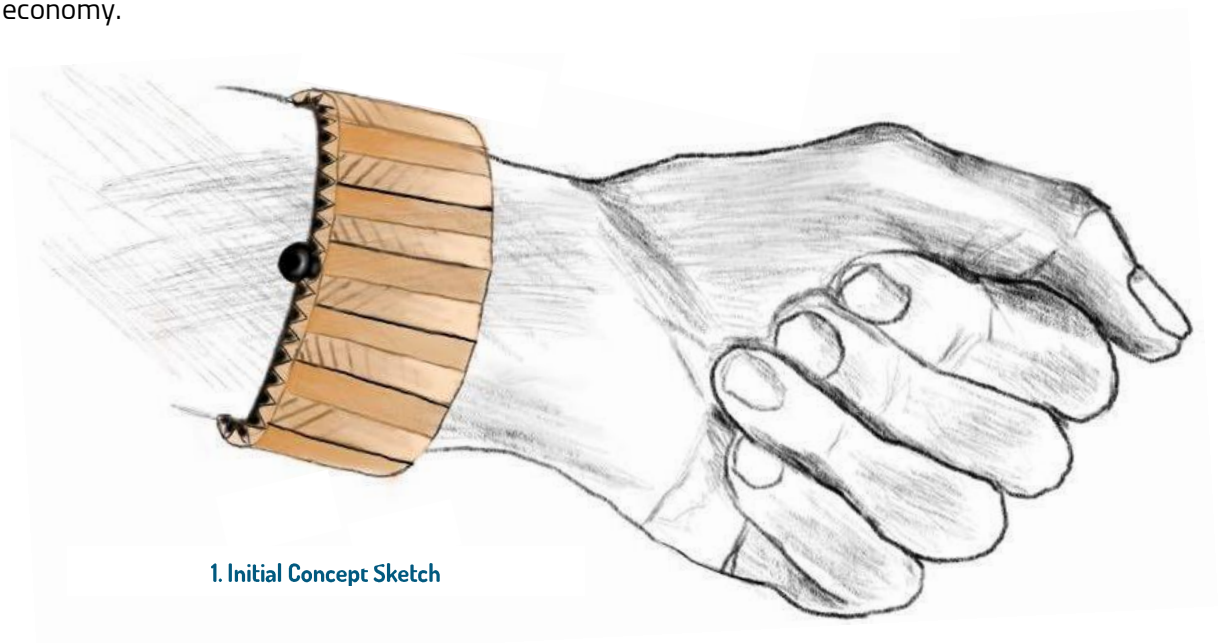
Market	Essential	The product service system and packaging should be easily integrated into the existing cosmetics and jewellery markets.
Materials	Essential	Low energy materials should be used. Weight, surface finish, durability, ease of manufacture and recyclability must also be considered.
Operation	Essential	The bracelet must be easy to operate and refill. It must be ergonomic and intuitive; the design should be inclusive for those with impairments or disabilities.
Quality Control	Essential	The bracelet must be inspected after manufacture and the ingress and retention capabilities tested thoroughly.
Reusability	Ideal	The bracelet should be reusable repeatedly with proper care. The more perfume bottles that it can replace over its lifetime, the better.
Shape	Ideal	The bracelet must have an attractive shape that fits in well with the brands aesthetic. It mustn't be too bulky.
Spillage control	Ideal	The sachet ingress system must be easy to use to avoid spills. The bracelet mustn't leak and it should be easy to tell when a sachet is empty.
Surface Finish	Ideal	The bracelet must be machined precisely and its surface finish should give it a premium appearance.
Target Market	Essential	The product service system and packaging must be suitable for a variety of target market groups of different ages and genders.
Weight	Ideal	The bracelet must be heavy enough so as not to feel cheap and tacky, but light enough so as not to cause discomfort.
Width	Essential	The bracelet must be wide enough to feel substantial and allow proper diffusion of the oil based perfume.

Concept Introduction

This concept replaces the idea of a disposable perfume bottle with a wearable, high quality, and functional piece of jewellery that maintains the branding and premium user experience associated with the existing system. This concept however, offers greater sustainability, an improved delivery system, a highly marketable and profitable product service system and solves several manufacture, disposal and transport problems, through the use of refillable product designed for a circular economy.



1. Initial Concept Sketch

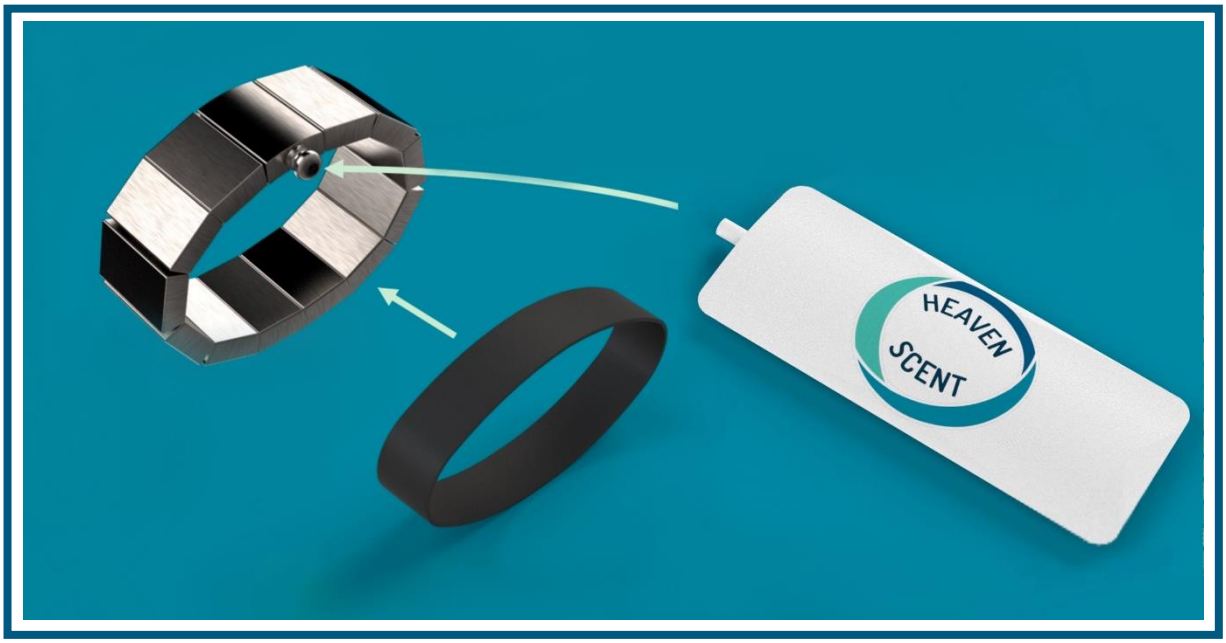
Bracelet

The aluminium bracelet is indistinguishable from traditional Jewellery from the outside, apart from some important branding aspects (a perfume bottle for many is a brand status symbol, my design is no different). There are however, several important functional factors. The central link has a small valve, which allows the user to refill the bracelet easily through the use of disposable sachets. The sachets are pierced on insertion by a small pin inside the valve that is concealed when the valve is screwed back upon successful refill. This mechanism would be patented to prevent competing brands from manufacturing their own sachets for use in the bracelet. The valve doubles as a mechanism by which the wearer can increase the flow of perfume: By tightening the threaded valve, the pressure inside the central link is increased and more perfume is squeezed out into the PE foam.

The aforementioned foam lines the inside of the bracelet, and serves to hold the perfume and allow the scent to diffuse through its porous structure. It allows for the retention of plenty of perfume which will provide ample scent throughout the day, with the distinct advantage of allowing the wearer to subtly reapply their perfume at will. Perfume is often worn for the benefit of other people, and regularly goes unnoticed by the user due to olfactory adaptation and temporary sensory fatigue. My design allows the wearer to be much more conscious of their own scent by giving them the option to adjust the diffusion rate at their own leisure without having to go to the bathroom and carry a bottle of perfume around. This grants them greater awareness over the product's function and benefits, and will help to merit positive user responses. The bracelet will have an adjustable clasp to fit different sizes of wrists of both genders, the foam itself will gently expand and contract allowing for constant pressure against the wearer's wrist, which will ensure a consistent release of scent and snug

Sachet

The bracelet is sold with a single disposable perfume sachet which the user will squeeze into the bracelet through the valve upon purchase. This system prevents the perfume from evaporating on the shelf, and also gets the customer used to the refill system. The sachet is made from heat sealed PET plastic, and would be printed with the brand's logo. The nozzle of the sachets contains a structural weakness that can be easily pierced by the valve mechanism without any spillage. When the sachet is inserted the user will gently squeeze the perfume into the bracelet and recycle the empty sachet.



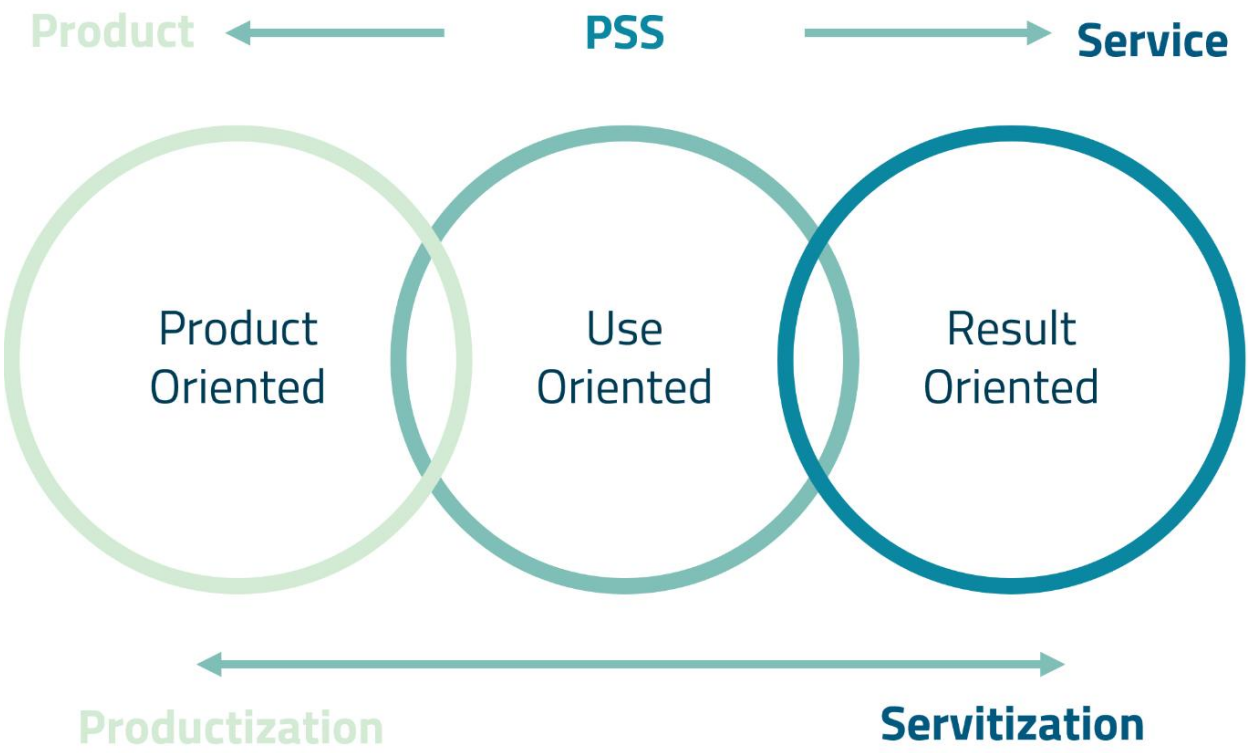
1. CAD Render of System

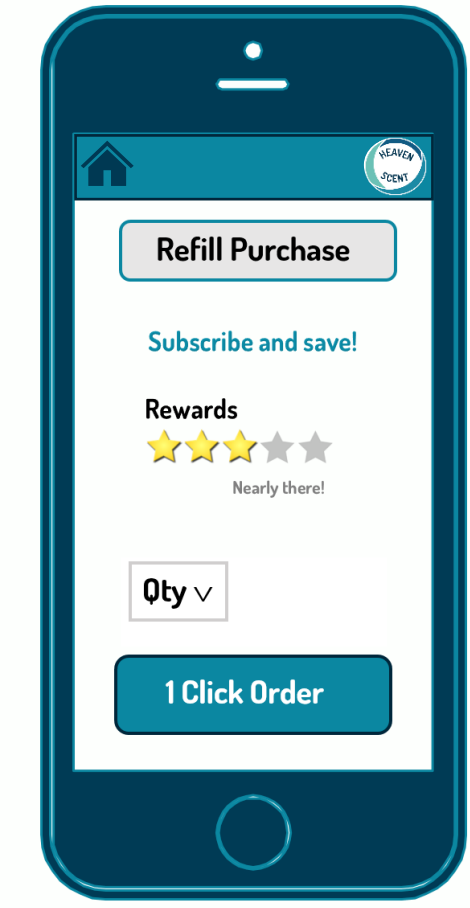
Perfume

The perfume itself is oil-based, causing greater viscosity than traditional alcohol based perfume. This is not a problem for my design as there is no atomiser mechanism to get clogged up. Oil-based perfume is beneficial for the skin, (my design would cause prolonged skin to perfume contact), as alcohol tends to dry skin out which negatively effects scent dispersion. Oil-based perfumes actually reveal different layers of scent, (top notes, middle notes and base notes) as the wearers body temperature changes. The high evaporation rate of alcohol also causes a sharp initial hit that subsides quickly. Alcohol based perfume is sold in larger bottles than oil or wax perfumes, but the aromatics themselves make up only 5% of the perfume: Oil and wax-based perfumes have a much higher concentration, usually around 20%. This gives a misleading illusion that alcohol based perfume is better value for money

Alcohol Base	Lasts 1 – 3 Hours	Harsh overbearing Scent	Short shelf life due to alcohol evaporation	Highly flammable	Removes natural body oils causing skin to dry
Oil Base	Lasts 6 – 15 Hours	Clean and true scent	Long shelf life	Non-flammable	Nourishes and moisturizes skin
Wax Base	Lasts 3 – 12 Hours	Subtle but clean scent	Long shelf life	Non-flammable	Does not affect the skin

Product Service System





1. Example of App UI

Refills

One of the key marketing and sustainability factors behind this concept is the disposable sachet refill system. After the initial investment in the bracelet the customer will ideally feel compelled to maximise its use and justify their expenditure by purchasing more sachets.

There will be two ways to purchase sachets, each suited to a different type of user; those who make use of the bracelet occasionally without it being a full replacement to traditional perfume will likely buy individual sachets as and when they are required. For those customers who utilise the bracelet on a more regular basis there will be the option for a subscription based service selling different scents at a reduced price. There would also be a reward scheme to encourage repeat custom, along the lines of buy 9 and get the 10th free, as well as complimentary sample sachets of different scents to increase the user's awareness of the versatility of the product and encourage customer loyalty.

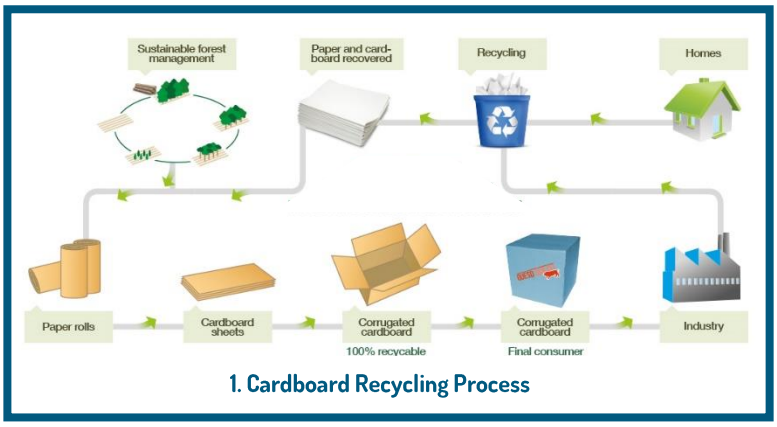
Second Stage Packaging

Both the bracelet and the sachets will require packaging in their own right: The bracelet will be sold in store and require attractive, brand appropriate packaging and the sachets need to be packaged to ensure their safe arrival through the mail. This aspect of the system will not be examined in any greater detail beyond this page, as it is secondary to the core concept and beyond the scope of this report.

Whilst secondary packaging is never ideal, it is worth bearing in mind that one Heaven Scent perfume bracelet would last as long as 100 perfume bottles with correct use, which would significantly improve the sustainability factor of the existing system by reducing the number of perfume bottle packets. In the same vein, using a centralised distribution system for the perfume sachets would prevent excessive packaging as seen by the Russian doll effect which is all too common with companies like Amazon who ship third party products in their own packaging. My packaging philosophy is to use the fewest number of materials and to design for easy disassembly and recycling.

Bracelet

The bracelet packaging is made from recycled corrugated cardboard, a cost effective, collapsible versatile and sustainable material that can be scored and folded to make structurally resilient shapes, and embossed and printed to create an appealing aesthetic. It is one of the most commonly recycled packaging materials and if it is sourced responsibly it will make no contribution to deforestation.



1. Cardboard Recycling Process

The outside of the cardboard would be coated with an aqueous solution to give it a gloss finish. This process is chosen in place of waxing or varnishing as both procedures create harmful by-products, especially when paraffin wax is used. An aqueous coating does not affect the cardboard's sustainability. The outside of the packaging would convey important product information including visual instructions for the product's use and a comprehensive ingredients list which would negate the need for a separate instruction manual. This information would be printed using offset printing in place of the more common lithographic printing which releases 80% more volatile organic compounds into the atmosphere which whilst non-toxic to humans, has a huge negative effect on fauna. A foam insert would be inserted into the cardboard shell to protect the bracelet, and would be made of a recyclable packing foam which could be removed easily from the cardboard.

Sachet

The sachet packaging needs to provide protection from any impact that might occur during shipping. The sachet valve is designed to be a structural weak point, and sufficient impact may cause it to fail and burst. I propose a recycled paper envelope lined with a biodegradable corn or maize starch based foam. This would allow the whole secondary packaging to be composted. Shipping information would be printed onto the envelope using the same environmentally friendly offset printing process.

1. http://www.fefco.org/corrugated-packaging/benefits-corrugated-sustainable

Customer Journey Map

Stage	Awareness	Consideration	Decision		Use		Loyalty and Advocacy	
Customer Activities	Learn about system from friends or family, online advertising, magazines, traditional media.	Compare and evaluate benefits over their own experience of different products.	Buy bracelet and first sachet in store or online. Alternatively receive as a gift.	Set up a subscription for repeated sachets or one click buy options.	Fill and wear the bracelet.	Contact Customer Care.	Order more sachets or start subscription	Share experience
Customer Goals	None as such	Find the best and most economical scent solution	Find and select products easily.	Easy order system.	Easy and intuitive to use repeatedly.	Get help if any issues were to appear.	Continue positive user experience.	Write reviews and give feedback
Touch Points	Word of mouth, social media, traditional media, fashion trends.	Website, reviews, social media, comparison sites.		Web page, App, email order confirmation.	Physical interaction with the product.	Phone, email, chat.	Web page, App, email order confirmation.	Word of mouth, social media
Experience	Curious and interested	Anticipation	Excitement	Pain of payment	Enjoyment	Frustration	Enjoyment	"I want to share this"
Business Goal	Increase Awareness and interest, gain publicity in the market.	Maximise number of website visitors.	Sell as many bracelets as possible.	Sell as many subscriptions as possible.	Maximise Customer satisfaction.	Retain Customer Loyalty, solve the issue quickly.	Increase subscription length and frequency.	Listen to customer feedback, turn negative experiences positive.
KPI	Number of people aware of the system.	Number of new website visitors.	Number of bracelets sold.	Length and number of subscriptions sold.	Reviews.	Number of problems, waiting time and success rate.	Subscription length, value and frequency	Viral coefficient, customer satisfaction levels.
Organisational Activities	Marketing Campaigns, offline and online PR work, Celebrity endorsement.	Marketing Campaigns, offline and online PR work, Celebrity endorsement.	Optimise Purchase experience.	Order handling, optimise online purchase.	Develop Product Service System.	Optimise Customer Service.	Marketing, product development	Customer service, online development

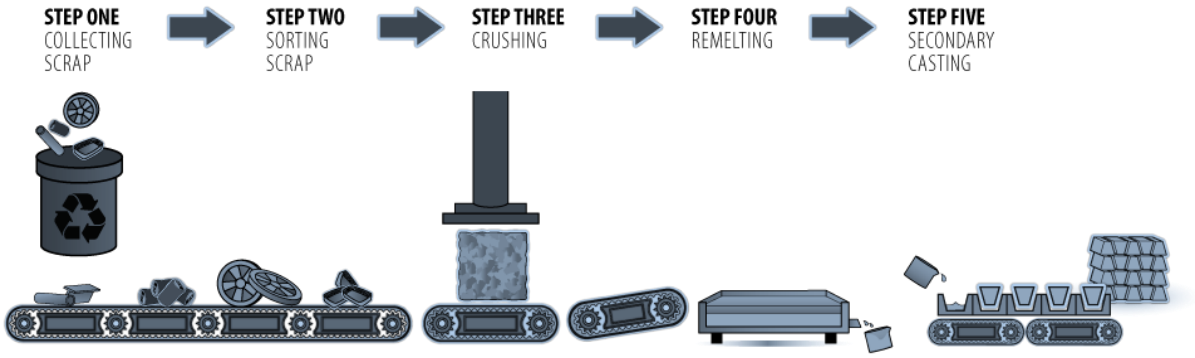
Material Consideration

Bracelet

The bracelet is made out of recycled aluminium; a lightweight, non-allergenic and corrosion resistant metal that has seen extensive use in existing jewellery and can be continuously recycled. Its low density allows even the boldest and chunkiest jewellery to be worn comfortably. Various options exist to improve the surface finish of aluminium including polishing grinding, anodizing and even powder coating. I would choose grinding over the more common anodizing process as it releases no harmful by-products and it can be used to create a visually appealing brushed finish that also helps to disguise wear.

1. Brushed aluminium ring

Aluminium is the most recycled and most recyclable material that there is; out of all the aluminium the USA has produced, 75% of it is still in use today. This is because recycling aluminium is 90% cheaper than extracting the virgin material, and hence there is a huge financial incentive for an effective and efficient recycling system. Aluminium has seen extensive use in high end consumer products in recent years, a trend that shows no signs of slowing down and that has seen positive response from the general public, particularly the younger generations.



2. Aluminium recycling process

Sachet

The sachet is made from PET (polyethylene terephthalate), a highly recyclable plastic that makes up 70% of plastic drinks bottles, and is made by the combination of two monomers: modified ethylene glycol and purified terephthalic acid. Its favourable properties include being inexpensive, shatter proof, food safe, thermally stable and its optional transparency. It is the most recyclable plastic with an impressive recycling rate of 52% in the European Union. It is expected that the user will dispose of the sachet along with other mixed recyclable waste for example drinks bottles.

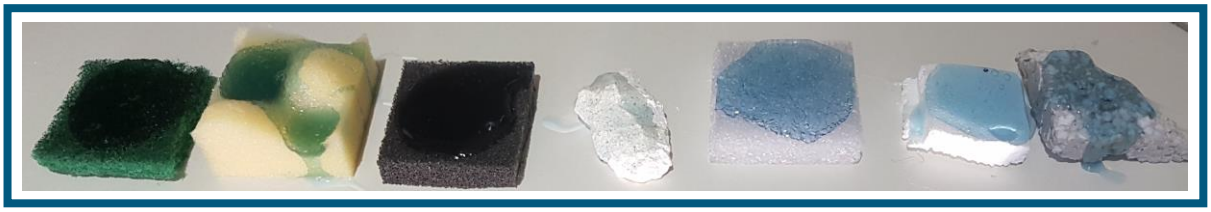
3, PET recycling Symbol

1. http://www.hsamuel.co.uk/webstore/l/jewellery/category%7Crings/occasion%7Cwedding/
2. https://www.bespokeguttering.co.uk/aluminium-recycling/
3. https://pixabay.com/en/recycle-1-pet-recycling-plastic-98854/

Foam

The foam is a highly specific component to the technical operation of the product, and therefore traditional research and CES analysis had to take a back seat to a more experimental method of material consideration. This is because there is no metric for measuring the diffusion rate of viscous oil through various foams of different porosity, under varying levels of pressure.

7 foam samples were obtained from Imperial College London to be tested with oil-based perfume. Where possible they were cut into shapes of similar size before the tests commenced.



The foam was tested for 4 properties; the ability to absorb oil-based perfume, the perfume retention time, the perfume retention time under light pressure and the flexibility of the foam.

The experiment setup consisted of pushing the oil into the foam to simulate the pressure increase from the valve mechanism, the time for the perfume to be fully absorbed was recorded. Once each foam sample was saturated with perfume, the time taken for all the oil to evaporate was also recorded. In order to simulate the light pressure on the foam when the bracelet is clasped shut around the wrist an experiment was conducted to measure the diameter of the squeeze out of the saturated foam. Digital Callipers were used for this purpose. A 400g mass was applied over a 6cm^2 section of foam, to simulate the expected pressure from a wearer's wrist. It is expected that this pressure will vary depending on the diameter of the wrist. The final metric by which the foam was chosen was its flexibility. This was evaluated holistically by how comfy sections of foam felt when worn around the wrist, and how much they impeded wrist motion.

Material	Full Absorption rate	Solvent retention after an hour (ranking/10)	Solvent Retention diameter under pressure (1Pa)	Flexibility (ranking /10)
Metal Foam	A few seconds	10	6.0	9
PE – foam 1	7 Minutes	7	4.3	10
Polystyrene and Concrete	Over an hour	0	0	0
Expanded Polystyrene	Over an hour	0	0	2
Extruded Polystyrene	About an hour	10	0	4
Memory PE - foam	A few seconds	10	6.4	9
PE – foam 2	1 minute	3	7.1	10

1. Foam under pressure

The numbers I obtained from my experiment allowed me to identify memory PE (polyethylene) foam as the clear choice. It was able to absorb the oil-based perfume almost immediately, and gradually diffused the scent over the course of an hour. Under light pressure only a small amount of perfume squeezed out and it was flexible enough to sit comfortable around the wrist under the aluminium bracelet. Whilst PE foam is recyclable, the global recycling rate is very low due to constraints on the number of facilities.

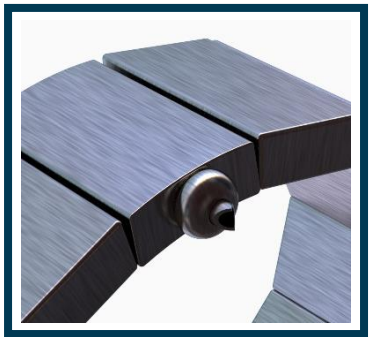
1.https://www.google.co.uk/search?biw=2021&bih=907&tbm=isch&sa=1&ei=9ySMWuuaEM7VgQaDrbnYDQ&q=silver:

System Analysis Tables

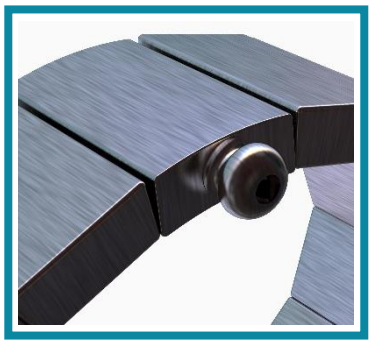
Geographical area	Europe	Asia	North America	South America	Africa	Australia
User age groups	Generation Z - (birth date mid-1990s to early 2000s)	Generation Y - Millennials (birth date early 1980s-mid 1990s)	Generation X (birth date mid 1960s-late 1980s)	Baby Boomers (birth date 1946-1964)	Silent Generation	
Material and design	Materialisation (e.g. traditional approach to materials specification)	Dematerialisation (e.g. use of less materials)	Material substitution (e.g. adoption of low-impact materials)			
Material origin	Virgin (non-renewable)	Virgin (renewable)	By-product waste (non-renewable)	By-product waste (renewable)	Second-life waste (non-renewable)	Second-life waste (renewable)
Product-service system (PSS)	Pure product	Product-oriented services (e.g. sales of product with services)	Use-oriented services (e.g. provider owns the product)	Results-oriented services (e.g. no product involved)	Pure service	
Product lifecycle	Linear flow (e.g. design for finite life)	Extended linear flow (e.g. design for infinite life)	Circular flow (e.g. design for after life)	Extended circular flow (e.g. design for after life)		
End of life	Landfill	Incineration	Composting	Recycling	Repair	Reuse
Manufacturing process	Manufacturing (e.g. traditional approach to manufacturing process specification)	Manufacturing substitution (e.g. adoption of low-impact manufacturing processes)				
Manufacturing organisation	Centralised	Decentralised (e.g. local manufacturing)				

Cells shaded in blue are relevant to the design.

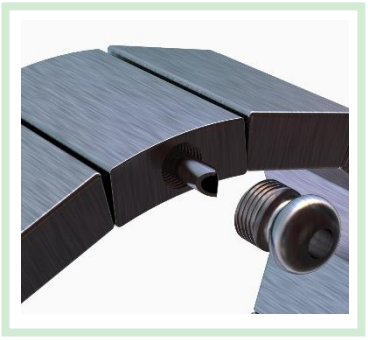
Engineering Analysis



1. Sachet ingress pin exposed (bracelet empty)



2. Sachet ingress pin concealed (bracelet full)

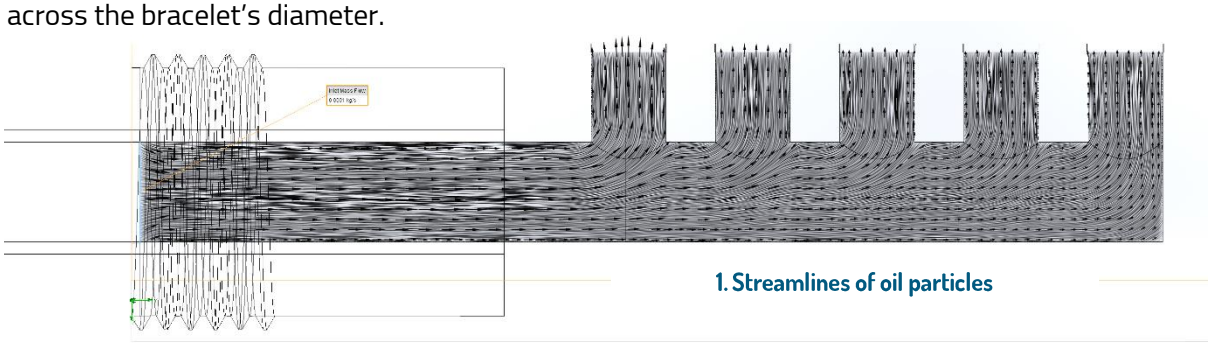


3. Exploded View to show thread

The Central Link of the bracelet contains a milled channel where the perfume is inserted, there are 4 egress holes milled into the wrist-side face of the central link. The ingress pin is a separate component that is mounted inside the channel and contains the valve to prevent back flow. Before the components are assembled the channel entrance is tapped with an M5,1 mm pitch thread. This guides the valve cover over the ingress pin. When the valve cover is screwed into the bracelet, the pressure is maximised and the perfume is squeezed out through the egress holes. At the very end of its positive travel all the perfume has been exhumed into the foam and the ingress pin is exposed, showing the wearer that the bracelet is ready to be refilled. After the refill process the valve cover is unscrewed by the user to the end of its negative travel and the perfume that has just been injected into the perfume is pulled back into the central reservoir.

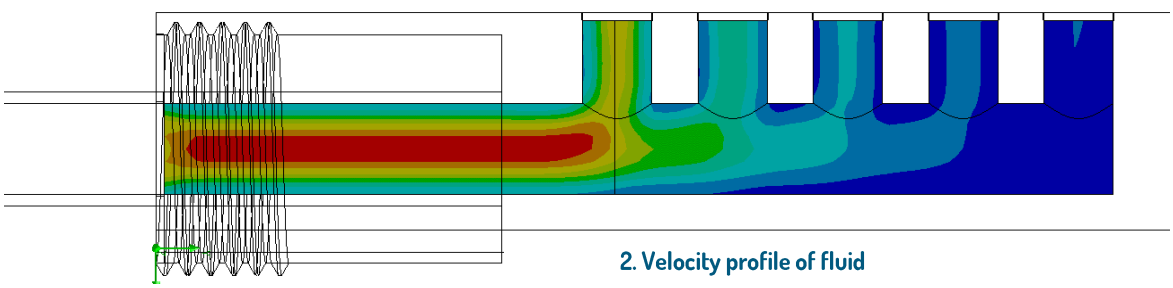
Solidworks Flow Simulation

To verify the efficacy of my engineering design a Solidworks flow simulation was conducted to gain a better understanding of the pressures and velocities involved, as well as identify the paths the fluid particles would follow through the model. The change in pressure of the hydraulic system was calculated and used to find the velocity and volumetric flow at each egress hole. Unsurprisingly the centre one contained the largest velocities. By changing the positioning of each egress hole repeatedly through the FEA process, I was able to create a relatively even flow rate across the bracelet's diameter.



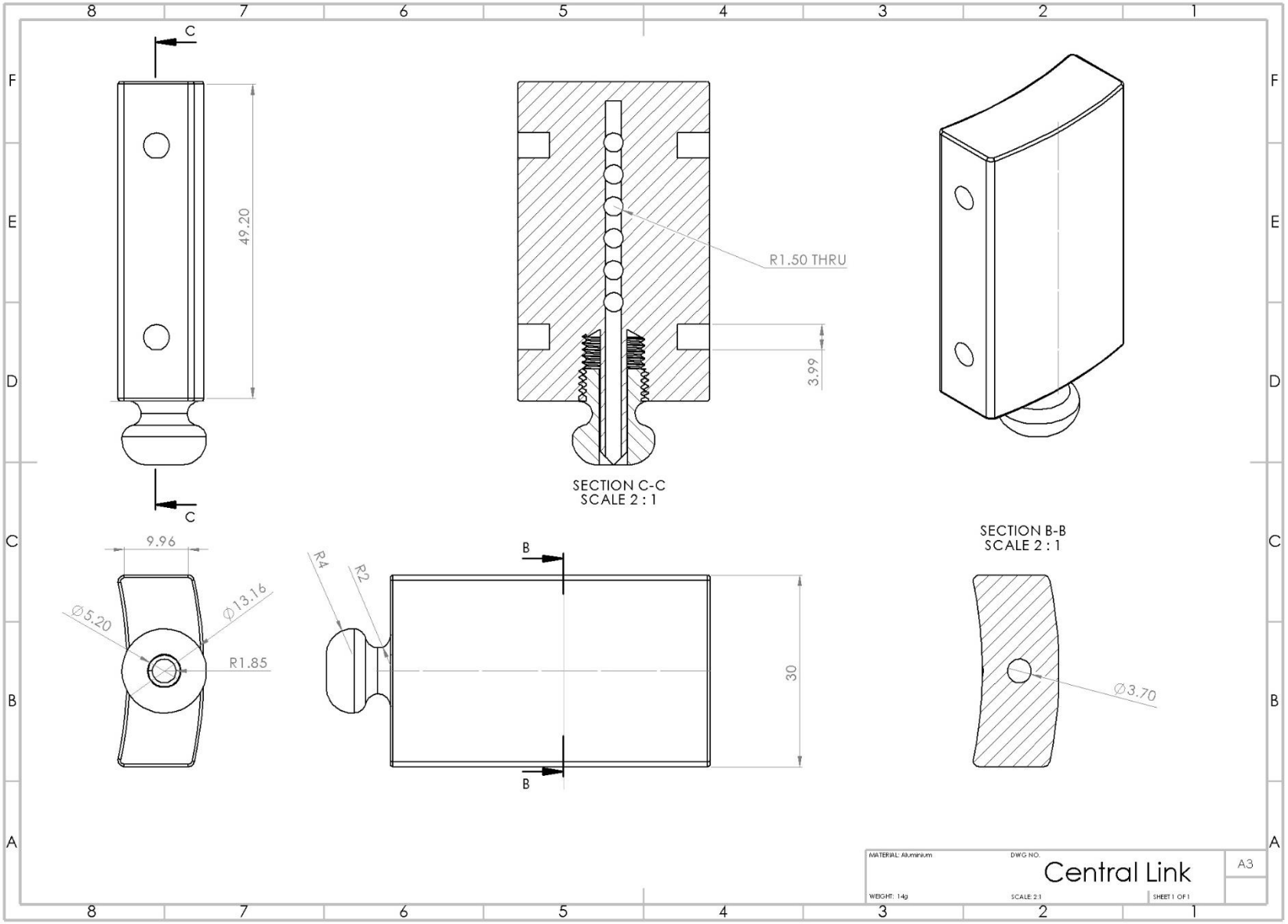
1. Streamlines of oil particles

Direction of pressure



2. Velocity profile of fluid

Engineering Drawing



User Testing and Final Prototype

I chose to design and build two sets of prototypes, which were user tested and iteratively improved upon throughout the design process. The first would be a non-functional sensorially accurate model of the bracelet, manufactured using the same materials as the real design. This would allow me to user test an accurate ergonomic model which would give the wearer a good idea as to how the bracelet felt when in use, and equally importantly; when not in use.

The second bracelet prototype was constructed at a scale factor of two as I was limited to using hand tools for my design, and would not have been able to work the aluminium without specialist equipment at the true scale. The purpose of this prototype was to demonstrate the working of the central link mechanism (the rest of the bracelet was not modelled in this prototype as it would have been of limited use given the scaled up size). Brass was used in place of aluminium on the valve cover due to limited availability of materials, but for the purpose of a functional demonstration the change made no difference.

PVC was used to model the sachet, as its experiential properties match PET accurately. The seams of the sachet were heat-sealed and stitched for strength. The aluminium stock was sawn by hand and drilled in a custom jig to ensure the holes all lined up. Elastic chord was passed through each segment and the corresponding foam and secured at the clasp. Four small neodymium magnets were mounted inside the end segments to model the clasp mechanism. It is possible to remove links to fit different sizes of wrists. The functional prototype was drilled and tapped to specification. The brass cover valve shaped on the lathe and threaded to match the aluminium central link. The egress holes were drilled on the drill press and the foam was mounted using adhesive. The functional model allowed accurate throughput and retention of the perfume, and received overwhelmingly positive user feedback

1. https://www.dreamstime.com/stock-photography-blue-thread-going-needle-eye-close-up-image30848082

Manufacture

Bracelet

Traditional jewellery can be handmade or mass produced. Making jewellery by hand is a fine art passed down the generations to skilled craftsmen who take pride in creating a unique and high-quality product. At the opposite end of the spectrum is mass produced jewellery. This process is for quantity over quality, with automated production lines or low skilled workers making many of the same product. Hand crafted jewellery is usually of considerably better quality than mass produced jewellery.

1. Silversmithing hand tools

The versatility of my system lends itself to both of these manufacturing principles, a high-end Heaven Scent perfume bracelet could have a handmade exterior in addition to the mass-produced core mechanism (through which the perfume flows) for a more expensive designer product. The more likely scenario, given that the bracelet will be sold by a perfume brand who sell products all over the world, is that a highly refined production line method will be used in the manufacture of the bracelet.

This section will detail the various large-scale manufacturing techniques available for my product and will conclude which is the most appropriate method in light of the insights gained from the prototyping process.

2. Industrial Aluminium milling

Aluminium can be manufactured from recycled material or refined from bauxite as virgin material. The most common manufacturing techniques are casting or milling: The bracelet links would likely be milled to shape, as high tolerances can be achieved and aluminium swarf can be recycled to minimise wastage. Extensive infrastructure is already in place for similar industrial processes. Jewellery is not usually milled but due to the complexity of the mechanism inside the central link an accurate method of manufacturing is required.

Sachet

PET is usually blow moulded in the production of plastic bottles. However, I would choose heat sealing as a more suitable manufacturing technique. This is in part due to the reduced cost and the difference in design; my sachets do not have a screw lid but are sealed around their whole perimeter. High frequency, ultrasonic and even induction or radiant heat sealing can be used with PET, keeping the manufacturing options open.

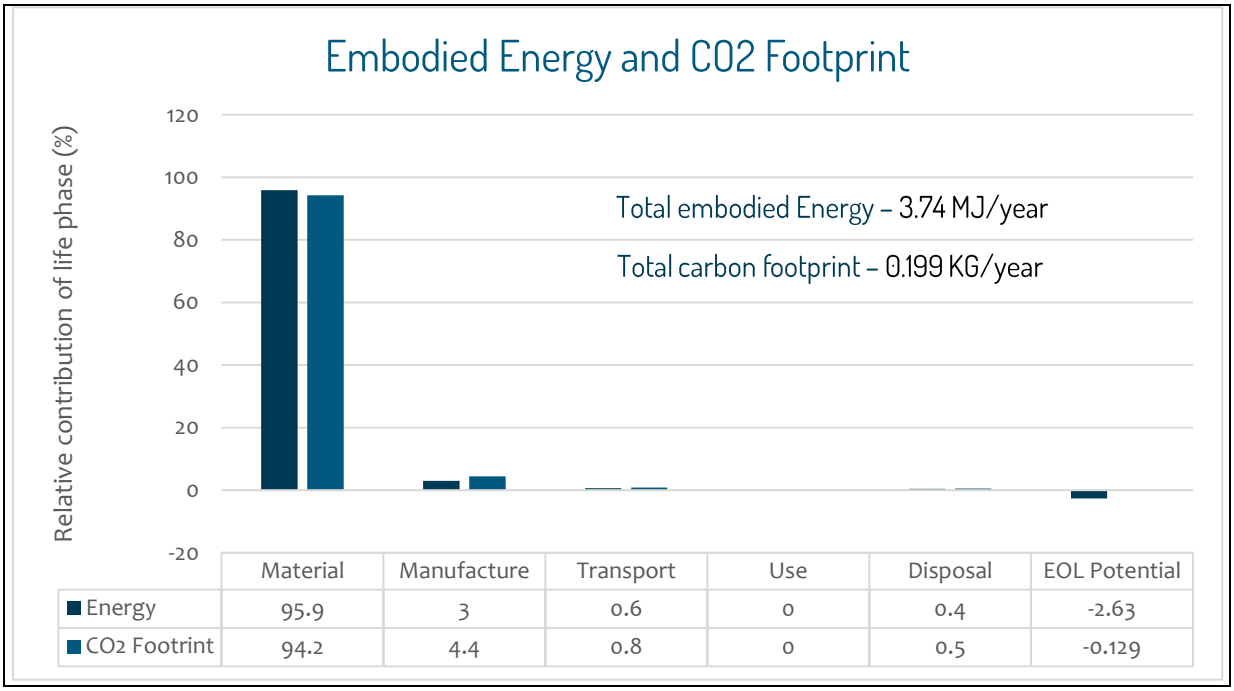
Foam

PE foams can take many different forms of varying rigidity, density and cell structure. The type I intend to use in my product bears some resemblance to polyurethane. It is extruded and mixed with a halogenated hydrocarbon which serves as a foaming agent. When the plastic is forced out of the die, the change in pressure causes the gas trapped inside to expand as the mixture is cooled and begins to solidify. This process is readily automated and can produce long continuously extruded cross sections of foam.

1. https://halswaymanor.org.uk/event/traditional-silversmithing-for-beginners/
2. https://www.trumpf.com/en_GB/products/machines-systems/2d-laser-cutting-machines/trulaser-3030-fiber /

Eco Analysis

In a similar manner to my technical analysis of the Estée Lauder perfume bottle, I conducted an eco-audit on my proposed design in order to compare both sets of data and show if any improvements had been made. The following charts include the bracelet, one empty perfume sachet and the secondary packaging.



Component	Material	Recycled content (%)	Part mass (kg)	Qty.	Total mass (kg)	Energy (MJ)	%
Bracelet Housing	Aluminium	Virgin (0%)	0.01	1	0.01	2.1	58.7
Bracelet Foam	Flexible Polymer Foam (LD)	Virgin (0%)	0.003	1	0.003	0.33	9.1
Carboard Outer Packaging	Paper and cardboard	Virgin (0%)	0.007	1	0.007	0.36	10.0
Packaging Foam	Flexible Polymer Foam (LD)	Virgin (0%)	0.005	1	0.005	0.54	15.1
Sachet	Polyethylene terephthalate (PET)	Virgin (0%)	0.003	1	0.003	0.26	7.1
Total				**5**	**0.028**	**3.6**	**100**

1. Table of embodied energy for different components

Conclusion

By comparing the two eco audits it can be seen that over 10 times less energy is used in the production, manufacture and use of a Heaven Scent perfume bracelet than in a single regular perfume bottle. The carbon footprint is also 100 times smaller. This is a pleasing result given that one bracelet can last for a much longer time than a single disposable bottle of perfume, and demonstrates that the system fulfils all the specification criteria.

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