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BSc: Independent Project

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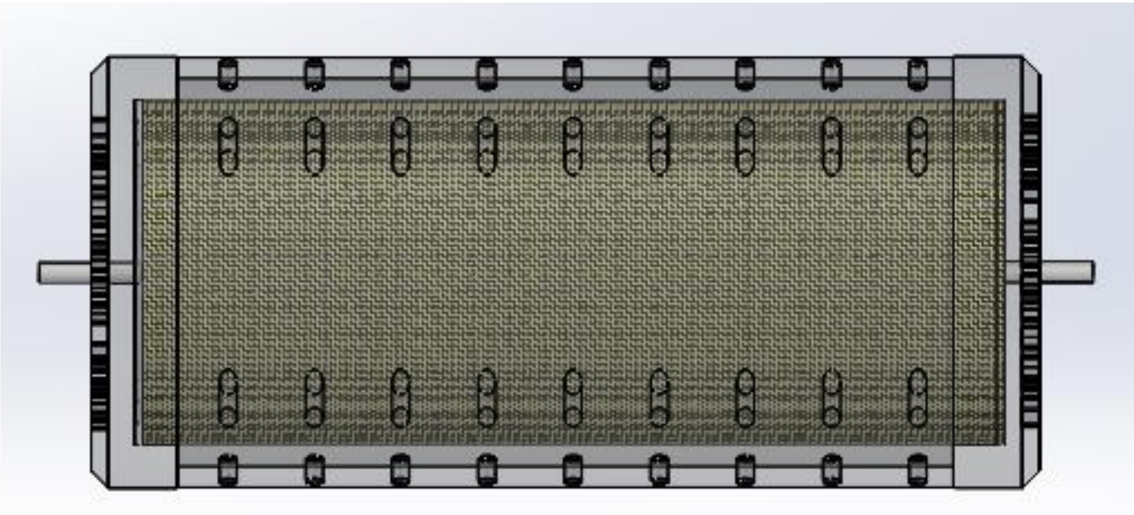
Graphene Filter

Word Count 10,000



Summary

The project is based on a new type of Graphene Filter System, ideal for sea water, or dirty water lakes, the device will be able to remove salt particles directly and other toxic particles without the huge resources it currently takes to transform sea water into fresh water. This device has many benefits and applications. It can be used with solar energy and Wind Turbines that will supply water pumps with energy to circulate the water either directly to urban areas or to treatment facilities where they further purify or add minerals, everybody should be entitled to clean drinking water, and this is a cost-effective method using sustainable energy, also the main by-product which is salt can be sold on to countries that require it for gritting road's etc. throughout this report I will be researching and developing ideas on how to apply the graphene to suit its environment and the customer's requirements.

Acknowledgements

Graphene Council

Knowledge of graphene and production.

Ashwin Dobariya

Introduced me to graphene.

Owen Latham

Outside the box thinking, help and honesty.

Dr David Adebayo

For giving a chance in life, showing love and compassion.

Sublade Neri

For helping me through my HND.

Jean Baptiste

For helping me through my HND.

Georgia Ward

For helping and putting up with me.

I would be nothing without help from these people.

Torrevieja Salt Lakes

Figure 1 Salt Lakes at Torrevieja

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Introduction

The object of this project is to bring clean drinking water to people without building expensive infrastructures. Using efficient and sustainable methodology's.

About

The Graphene Filter will transform dirty and salt water into a clean drinking water. Using a Graphene Oxide Membrane alongside a carbon chamber, it utilises a sieving methodology to filter water, the technology has been available since 2004 but never used towards a filtration system, Graphene is a relatively new technology founded by Manchester University, it has many properties one being conductivity, this area is heavily focused on because graphene conducts at 1 atom thick, therefore a mobile phone for example of the future could be made thinner than the film that covers the screen of a phone you buy from a shop today. However other properties include strength 200 times greater than steel, but most interestingly to me is that it only allows water molecules to pass through it due to its Nano structure which we will discuss further in detail later through the report.

Graphene allows only water molecules to pass through, removing toxins and chloride, the purpose of this filter is that it reduces energy consumed and wasted by the current reverse osmosis techniques, an efficient and sustainable method of solving the water crisis we currently face. The Graphene Filter could be used for example, as part of the main water way systems we currently use, or smaller independent installations for small villages or towns close to dirty or saltwater oceans and lakes.

By-Product

When used in the ocean the filter operates at its maximum intended use by utilising the by-product which is chloride/salt, this will be collected and sold on to countries that require grit or table salt, the method of removing the chloride will help maintain salt levels in the sea which is important for sea life and ship buoyancy. Using Russian Doll methodology, it purifies the chloride due to the design of the chambers making it viable to use for table salt as well as grit and other products.

Waste and Toxins

Waste is collected and brought to land and disposed of accordingly, reducing toxins in the sea which we as humans have put there through accidents, disrespect and negligence, thus it is detrimental towards sea life and affects the food chain.

Oil

Toxins such as oil do not mix with water and forms a film on top of are oceans, this kills the environment it absorbs, my filters will be position near the surface to remove oil as well, and then separate it inland, and hopefully reuse it to reduce oil consumption in general and maintain the pumps of my system with it.

Human Impact on this world

We are the only species that's kills for reasons other than survival, we are a problem to this planet, we are driven by greed corruption and selfishness, and this leads to neglect, however we don't intend to be bad we intend to be good, we just need to be educated for the sake of are children and there's, we need to change the way we approach this world.

Water Crisis

We can only consume 0.7% of water on this planet, leaving 99.3% unused due to toxins. It does not take a genius to work out that we are going to run out of water, and in some places, this has already happened.

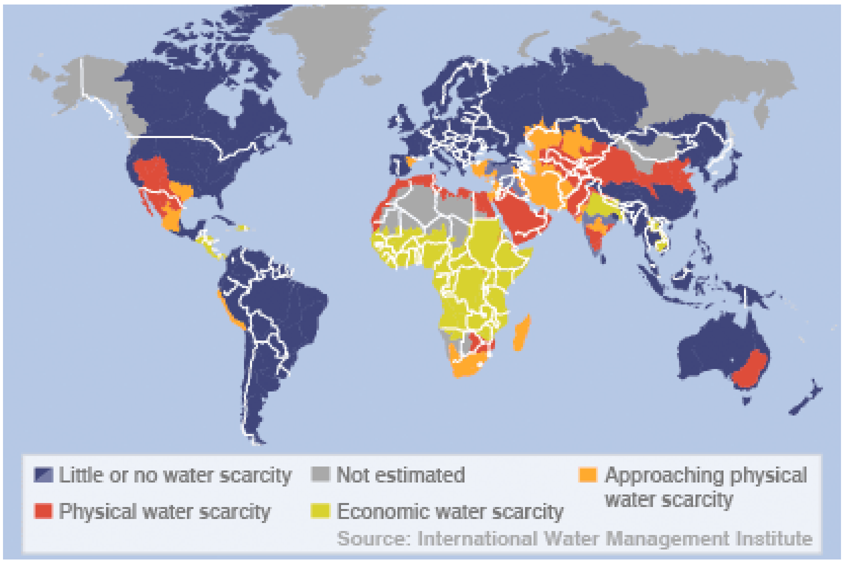

Figure 2 Map details global water stress (BBC News, 2006)

Growing up as a child seeing the troubles in Africa regarding fresh water has haunted my mind for a long time, and nothing much has changed, seeing children die due to lack of water is disgusting, people would sooner cause wars and send rockets to space than tackle the real issue.

Benefits

This system is good for oceans and freshwater lakes. Not only does it provide clean drinking water it cleans the sea of toxins as it does so and utilises by-products in an efficient sustainable manner.

My Vision

My plan is to design a filter using Graphene and Carbon, the filter can be part of a big operation or individual depending on environment, fundamentally it will achieve the same goal, fresh water, with minimum energy consumed and wasted, utilising wave power, wind turbines, solar panels and battery backup systems will run the pumping programme assigned to installations.

People Required

- Environmentalists
- Engineers
- Construction Workers
- Graphene Manufacturers
- Design teams
- Research and Development
- Product Manufacturing
- Accountants
- Water treatment specialists
- Technical support
- Passionate people
- Waste disposal technicians

This type of project would require a huge number of skilled workers and helpers to achieve the dream on a big scale. Also, it provides jobs for people which helps towards a better way of living, a standard we here in the UK take for granted. For example, Africa is a rich country in terms of resources but lacks fresh water, if we give them the water they need then Africa will flourish.

Reality

This filter in my mind will work, I do not accept it cannot be done, and if this becomes my life work then so be it. All that is required is attention to detail to produce a worthy vessel that can withstand the environment in which it is to operate. I have been knocking on the door of the Graphene Council and they can supply in bulk the graphene, plus this will boost the graphene industry ultimately reducing the cost of the filters which means affordability at every level.

Funding

No doubt to build this product will need to be funded, but it’s an investment as the salt collected will pay for installation costs. For example, I think Africa deserves to sell the water and by-product to other countries under fair trade regulations but never to their own people, this would boost the economy.

Ball Rolling

It’s time to begin the design of the Graphene Filter and we need a plan of attack, a critical approach is to be undertaken.

Plan of Work

Table 1 0-3 Month Plan, Gantt Chart

PDS	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
Idea	SCP											
Ability		Research										
Customer Requirements			Client	Focus								
Functional & Product Specification					Design							

Table 2 3-6 Month Plan, Gantt Chart

PDS	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20	Week 21	Week 22	Week 23	Week 24
Functional & Product Specification												
Review Design												

Gantt chart enables us to set targets and show a future layout, the drawback is Gantt Charts tend to change from start of design to finish.

Table 3 6-9 Month Plan

PDS	Week 25	Week 26	Week 27	Week 28	Week 29	Week 30	Week 31	Week 32	Week 33	Week 34	Week 35	Week 36
Test Market												
Introduction												
Critical Evaluation												
CAD Design												

Gantt chart enables us to set targets and show a future layout, the drawback is Gantt Charts tend to change from start of design to finish.

Potential Problem Analysis (Kepner Tregoe**)**

Table 4 (Kepner Tregoe)

Potential Problem	Consequences	Possible Causes	Prevention	Contingency Plan
Graphene oxide Membrane	Sea and dirty water contaminate fresh water supply	Faulty Material, Bad Batch	Check Quality	Maintenance, competent person
Salt	Blocks Filter	Build-up of Salt Particles	Pump System	Design with Pump
Material Selection	Rust	Sea water, oxidization	Suitable material	Select correct material

Kepner Tregoe chart identifies problems that could arise due to environment. This chart helps Highlight Problem areas before we even begin the design process.

Stakeholder Analysis

Who has an interest in my design?

Table 5 (Stakeholder Chart)

Stakeholder	Area of Interest	What is considered valuable	Hopes, Aspirations for Design	Fears and Concerns
Me	Where there is a lack of fresh water.	cost, quality, efficiency, sustainability, impact, equity.	That it is mass produced and sold as an efficient salt water solution, that uses the salt as a by-product to sell as grit to pay for materials and installation costs over a period.	They don’t use it as it upsets other companies. Not tried and tested.
Customers	Lack of Fresh Water.	Cost and quality of Product.	A world where Fresh water is readily available	Faulty products, reliability.

This chart shows people who have an interest in my idea, so far, it may change to include other members.

Product Design Specification (PDS)

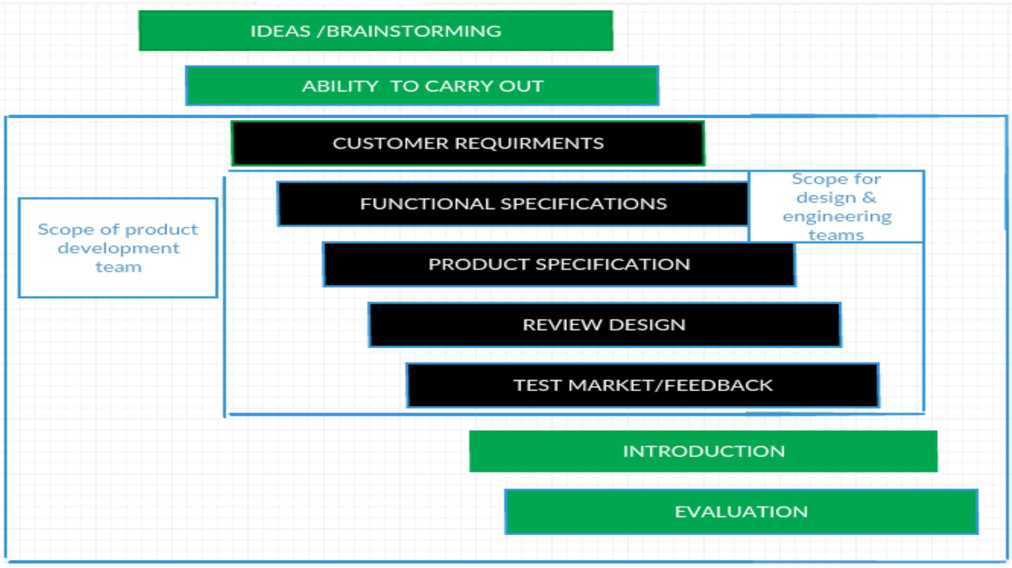

Figure 3 Product Design Specification

PDS shows stages of development in an orderly fashion.

PDS, Research and Development (R&D)

This PDS report on the Graphene Filter is broken down into stages. Many of these stages come together to form what is known as, Research and Development (R&D). R&D is a huge part of a PDS, from initial ideas to the Evaluation. R&D will be involved amongst other factors and this forms a PDS, which is a structured method of how to Design, Invent or Innovate a product or Process as demonstrated throughout this report.

Ideas

To design such a device, I need some ideas which helps me develop a picture in my mind and an understanding of how to do this.

Idea 1

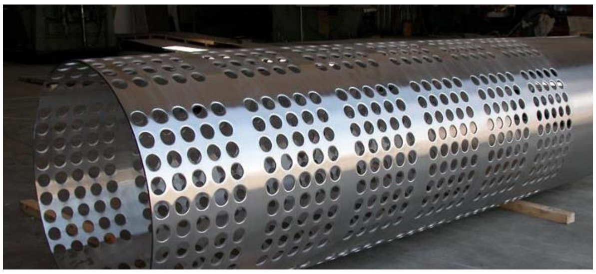

Figure 4 Holed Cylinder (TubiSteel, 2018)

Holed out silencer casing, an idea for my housing which would let seawater in without letting in sea life or debris. Length is important, the longer the filter the less chance of blockages and stress, a sieve method as oppose to a compressive method is to be used.

Idea 2

Figure 5 Silencer (Direct Industry, 2018)

It's a ducting silencer, but I like its shape, and the mesh on the inside gives me ideas of filtering methods, a good shape for surrounding water, an inlet and an outlet, simple but effective design.

Idea 3

Figure 6 Carbon Filter (Hongtek Filtration, 2018)

Use of a Carbon filter to reduce salts and slow down salt impact on the graphene oxide membrane.

Idea 4

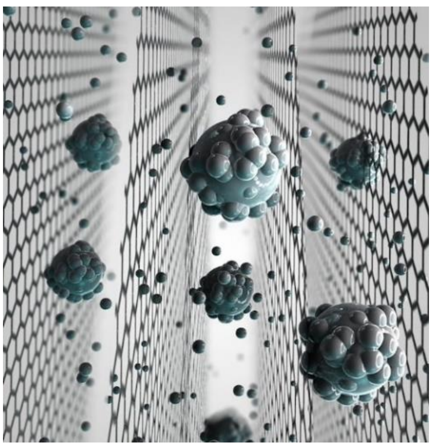

Figure 7 Graphene (Robinson, 2017)

Graphene, best filter there is in oxide membrane form, final step process in transforming the Carbon Filtered water to complete fresh water.

Idea 5

Figure 8 Waste Pipe (Wickes, 2018)

Waste pipe, simple idea, pumps water and salts.

Idea 6

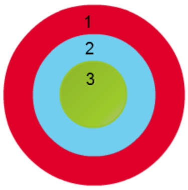

Figure 9 Concentric circle design (Russian Doll Method) (TutorVista.com, 2018)

Russian Doll Method.

Idea 7

Figure 10 Barrel Design Idea (Jaws) (Mantaray Pictures, 2016)

Yellow barrel design from the film Jaws, holds it Buoyancy, bright colour indicates its whereabouts from a distance.

Drawings

Below are 4 rough CAD drawings of what I think a Sea Water Graphene Filter should look like using the ideas above for creativity, each drawing is slightly different, and improved versions are used for a final draft concluded with a Pugh and Matrix Chart.

Design 1

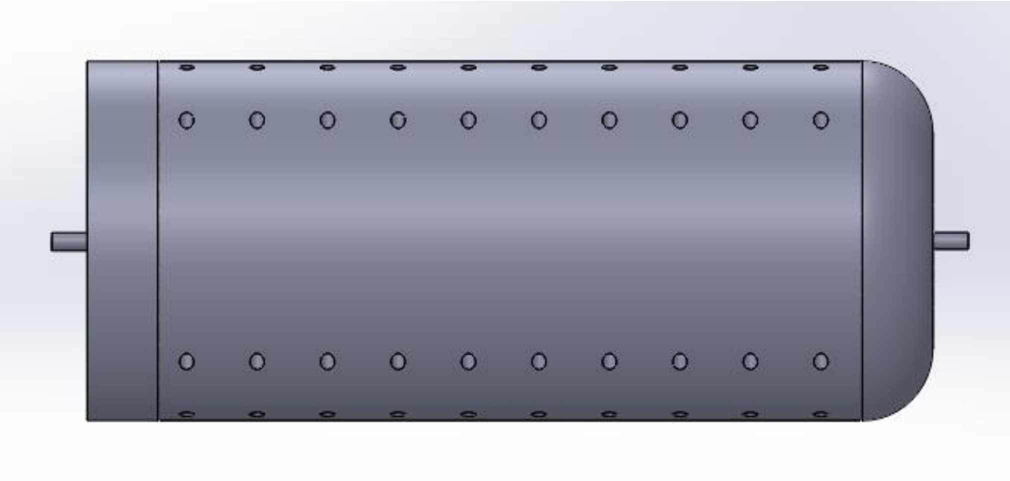

Figure 11 Design 1 Graphene Filter

Design 2

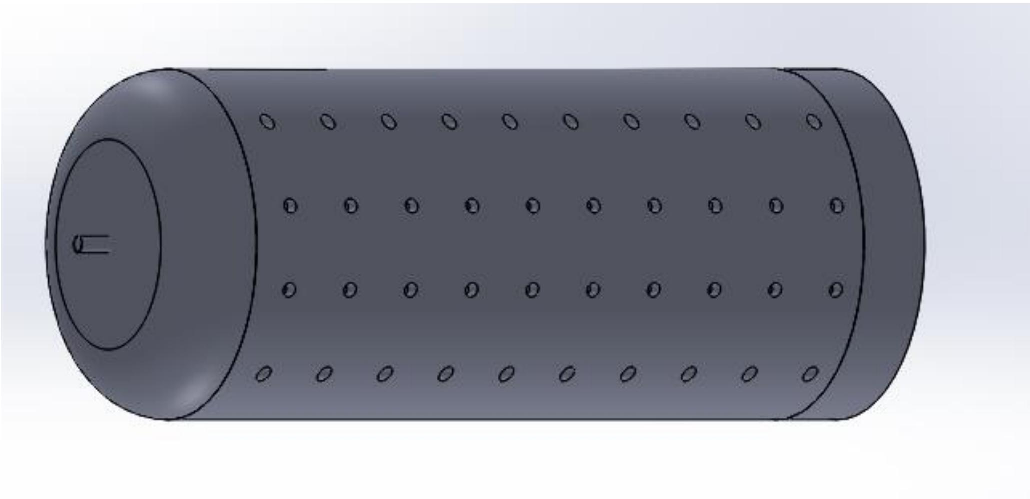

Figure 12 Design 2 Graphene Filter

Added more holes to case.

Design 3

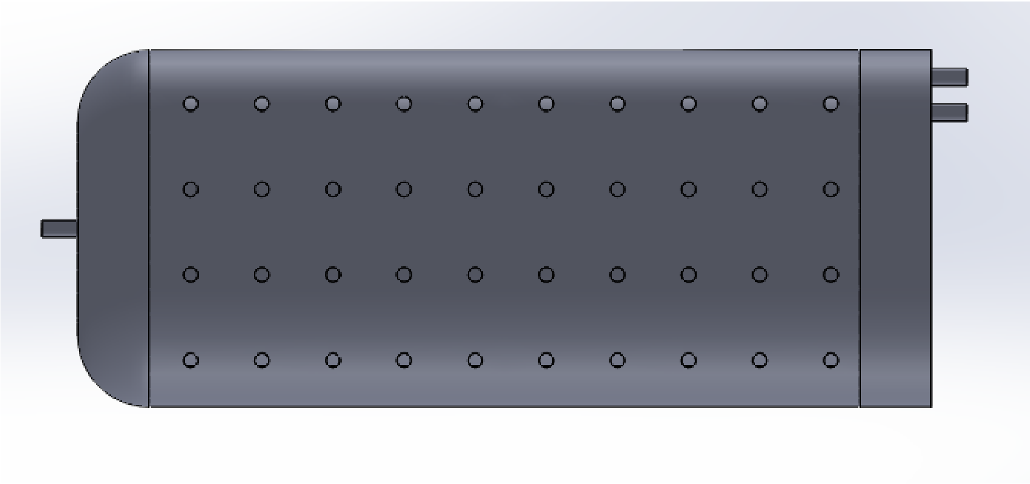

Figure 13 Design 3 Graphene Filter

Added salt water waste pipe.

Design 4

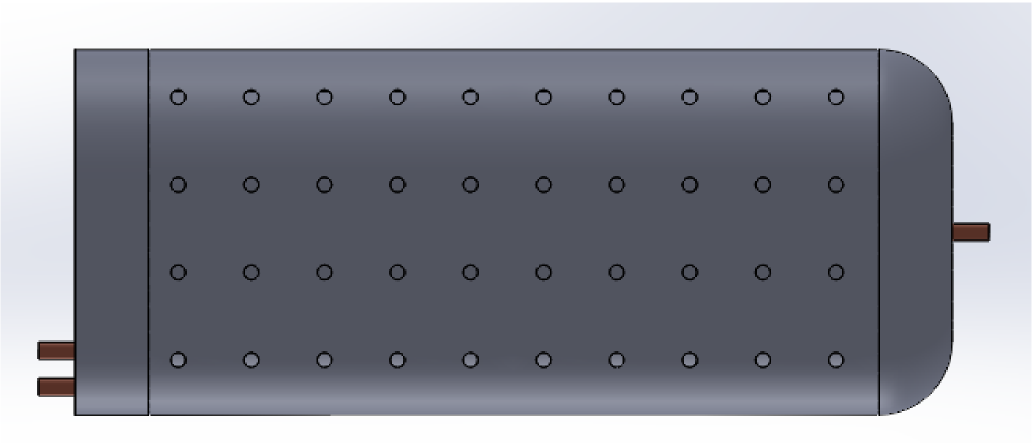

Figure 14 Design 4 Graphene Filter

Moved pipes to bottom as sediment would naturally sink, also pipes have been oxidised.

Choose Drawing Using Pugh and Matrix

Table 6 (Pugh and Matrix Chart Comparing Design Drawings)

Criteria	Ideal	Design 1	Design 2	Design 3	Design4
Cost	S	+	+	+	+
Practicality	S	-	-	-	S
Ability	S	S	S	+	+
Salt By-product	S	-	-	-	+
Inlet Holes	S	S	+	+	+
Waste pipes	S	S	S	+	+
Efficiency	S	S	S	+	+

Sustainability	S	S	+	+	+
Total +	0	1	3	6	7
Total -	0	1	2	2	0
Total Score	0	0	1	4	7

Decision

Design 4 is a three-layer system, with the outlet pipes in the correct position (at the bottom). Utilising Carbon and Graphene Filters, as I began my drawings I improved on its features with further designs, concluding in a final design, drawing 4, the reason is because it can remove salt from seawater and we can reuse it as grit or table salt, this reduces the cost of the products material and installation as it pays for itself over time, it also keeps the density of water the same for ships and the likes when transporting loads through seas. It has also had the end caps reshaped for aesthetics. It has 3 outlet pipes that allow for water to move, pipe 1 in the centre to allow the fresh water to be taken to the reservoir via a slow pulling pump, pipe 2 is the one that removes salt build up and reduces the duty on the Graphene Oxide Membrane and pipe 3 is for Bulk waste water which enters from the outer shells first layer.

Design 4 finished design idea

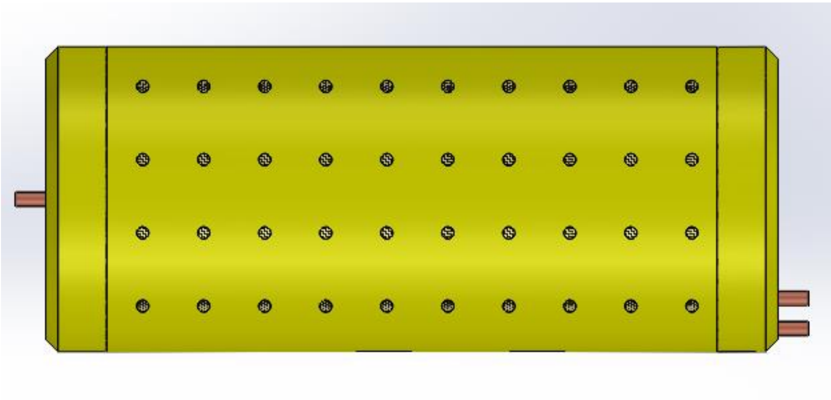

Figure 15 Macroscopic View Graphene Filter

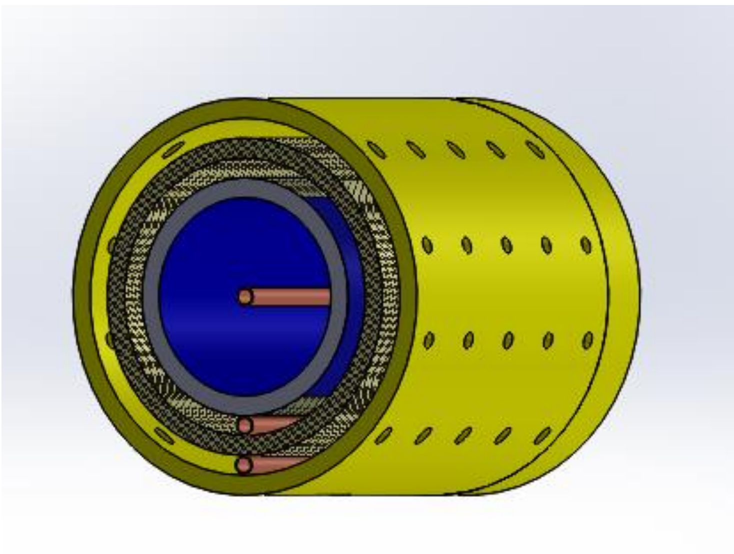

Figure 16 Section View Graphene Filter

Ability

I have an idea of how I want it look and what I expect it to do, fact is there is no research in terms of filters for graphene, so this is purely my take and initiative. I will be aiming to design this in CAD and if I can obtain the materials I would like to build a small prototype, to prove to me and others if it works or not.

My vision is that by connecting fresh water and waste pipes we submerge the device in sea water, slowly it sinks just below the surface, water penetrates the filters, at 35 grams of salt per litre of water, this will be a steady process, once submerged, we can start the pumps. There are a lot of solids to reduce and eradicate, the main one is salt.

Salt is a by-product of this filter, the equity of salt is enormous, but through current methods it is hard to obtain, salt is normally evaporated from sea water, or by force which takes too long and wastes too much power. In this case salt is extracted and densified via the Carbon Filter, little evaporation is required, and the salt is purer and easier to obtain.

The Graphene Oxide Membrane stage, again cylindrical in design, allows only water molecules through it when meshed in the correct manor. It is 200 times stronger than steel and has many other properties. Graphene Oxide Membrane literally gives fresh water instantly, no treatment facilities required, currently turning seawater into freshwater is a very expensive and inefficient method.

Housing Filter

First design a waterproof, sea worthy vessel, a cylinder shape, that is to situate just beneath the surface of the water, this can be achieved with the correct choice of materials and buoyancy aids, the housing will allow sea water through but not sea life or debris, the design of the housing is crucial in terms of how long it will last, sea air and salts erode metals without protection quickly. I think the housing should be made from a tough plastic to withstand weather conditions and reduce rust, the design is concentric which means there are cylinders within cylinders (Russian Doll Effect), they do not touch each other and are fixed in place by using end caps with ridges that are sealed correctly, they also secure the waste and fresh water pipes.

Carbon filter

The carbon filter which is cylindrical in design will sit inside of the housing concentric, seawater will pass through at this point but not a great deal of toxins remains in the water, Carbon is very good at removing solids in water but not salt. There is also a waste pipe in this section that filters out debris which could interfere in the next phase of filtering, the waste pipes are a crucial element in avoiding blocked filters, they work via pumps running from main land using either turbines or solar for efficiency and sustainability, if the filters clog it puts too much pressure on the pumps and they will stop working.

Graphene Oxide Membrane Filter

The final stage of purification, a pump from mainland sucks the fresh water through, it draws steadily on the graphene oxide membrane as not to clog the membrane, this could happen if the fresh water pump produces more power than the waste pumps. The waste pumps are constantly working to remove debris and salts, a slow and easy draw on the fresh water pump is the best method in my opinion and I have allowed that chamber to hold more fresh water which reduces the chances of clogging the Graphene Oxide Membrane.

Pipes

- Bulk Waste Pipe (Sea Water Chamber)
- Salt Pipe (Carbon Chamber)
- Fresh Water Pipe (Graphene Chamber Centred)

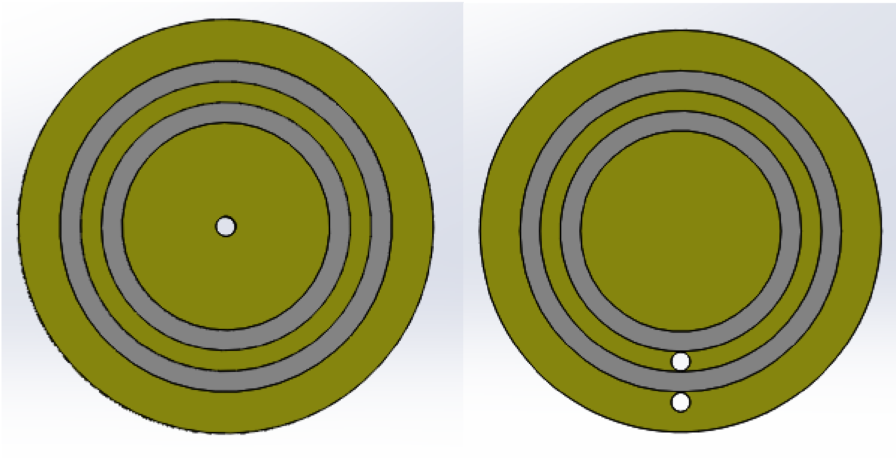

Figure 17 End Caps

End Caps

End caps have 4 extruded 2mm diameter guides to mount to housing, it also helps when securing the filters in place as it has grooves for them to fit into. By using water proof resins that not only seal the vessel but hold parts in place, it has ridges that hold the Chambers then by adding resin we seal all the joints, the reason for this method is because anything welded with metals will rust and erode and is expensive and reduces product life, sealing the capsules so no foreign elements can penetrate the Carbon or Graphene Chambers is the main reason for this.

Tolerance End Caps

Tolerance for HDPE (0.001mm + -) = 5.001mm width of groove allows for easy fit of chambers, allows for expansion of the graphene and carbon chambers, allows the resin to penetrate deep forming a sealed unit.

Buoyancy

Weights and Foam that will be provided will be used to balance the Filter, sea water and fresh waters have different densities around the globe, Salt water, has a density of about 1027 kg/m^3 at the surface and we are just below. There are two main factors that make ocean water dense.

- Temperature
- Salinity

Testing Water

To test the water, we will use a Ph meter and Electroconductivity meter (EC meter), the Ph will be monitored for acidity and alkaline, and the EC meter detects the number of solids in the water, at each level of filter there will be a test meter, I suggest they are put on the waste and fresh water pipes mainland, for ease of maintenance before buffering commences.

Buffering

Buffering occurs after the fresh water hits mainland, graphene removes every particle so there are no minerals what so ever, and the PH may be high or low, buffering allows for the addition of minerals and PH up or down, by adding are own blend of minerals we can match water to regions for sale.

Conclusion

By judging my initial idea and then adding my input and visionary thoughts, I have concluded that it is a valid product, it could be made in any size, it could be used for any type of water and materials are readily available, Graphene Oxide Membrane however is the expensive part, but I think when the manufacture picks up it will become readily available and cheap because of the equity of material, and what it can do. Although the Ability Section briefly touches on components, full specifications of components will be given, see calculation section and material section to justify the Product Specification.

To begin design I need to decide dimensions of a prototype, I will use CAD, SolidWorks specifically to carry out the design. From that point I can use the dimensions for Product Specification and store the files on a USB, I could then take the files to companies that specialise in CNC machines and plastic moulding as a means to get my parts manufactured, I can readily buy a Cylindrical Carbon mesh, just cut it to size, adding the Graphene Oxide will be done manually and the cap seal once it is in place. A prototype is ready to demonstrate. Size justification is simple, Graphene Oxide is expensive, a small Prototype will be used which is cost effective.

I am unsure as to how much this product would cost without clarifying materials and man hours, if I design using CAD, using the mass measure setting will indicate a price of material, and I will assume man hours are paid for, but we need to clarify with potential customers to see if they like my idea first.

Customer Requirements

Upon my design, I need some feedback, its ok having a biased opinion on my own design but we need some real unbiased opinions, so I selected the most frequented questions, and put it out as a questionnaire.

Table 7 Customer Requirements

Question	Answer
Do you think water should be available to everyone, everywhere, at any time?	yes
Why is this not the case?	Cost of infrastructure, Capability.
Have you heard of Graphene Oxide Membrane?	Heard of Graphene, but not in a filter form.
If I told you Graphene was the best filter for water purification, was more cost effective and efficient, would you be interested in such a device?	Yes, how much is that going to cost.
What would you expect to pay?	No idea, because I never seen one.

Focus Meeting

I ended the questionnaire and began a focus group with lecturers, who understand my idea better then joe public.

Outcome

After a review with Loughborough College, they say complete your Product Specification, then come back for a review, as we think you have a good idea, but you need to be more detailed in exactly what you are doing as CAD is merciless, you print it out wrong, it costs money.

Functional Specification

- Removes salts and dirt from water in 3 simple steps.
- Sustainable
- Efficient
- Pays for itself if you remove the salt and sell it
- A purer method of removing salts
- A much cheaper option when compared to the current 4-6 step reverse osmosis process
- Entitles everyone to clean water, everywhere without building infrastructure
- Big and small installations available
- 100% green

How it Works

Schematic Diagram

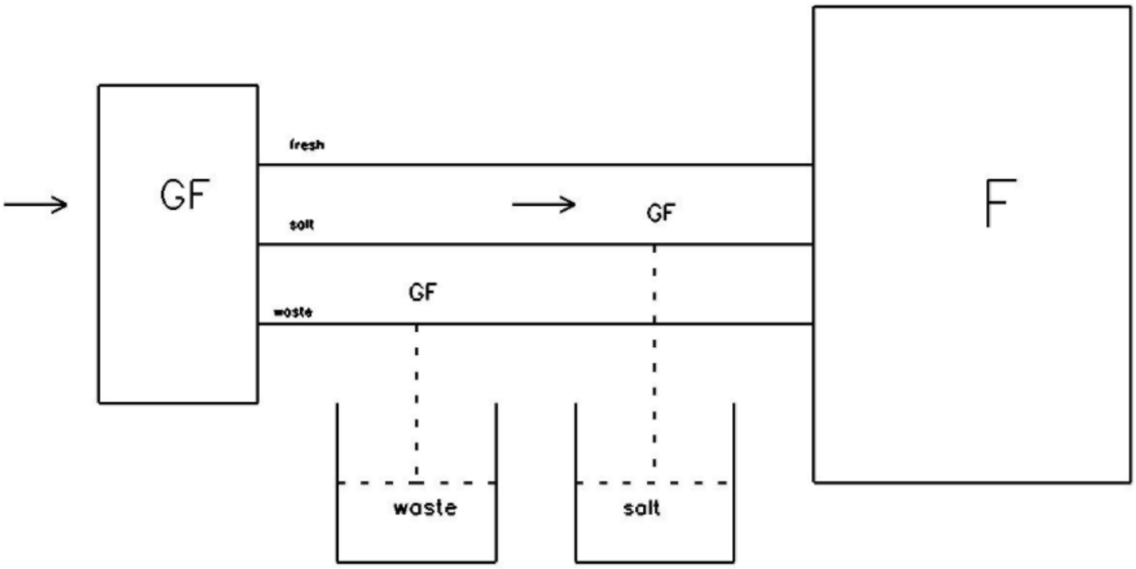

Figure 18 Schematic Drawing

Schematic diagram illustrates the method of removing toxins and salt from sea water, the fresh water from the filter is sent directly to the reservoir, the waste and salt will be sent to further processing plants, before they arrive a graphene filter is installed along the pipes to purify the water and send that to the reservoir where elements such as oil will be separated.

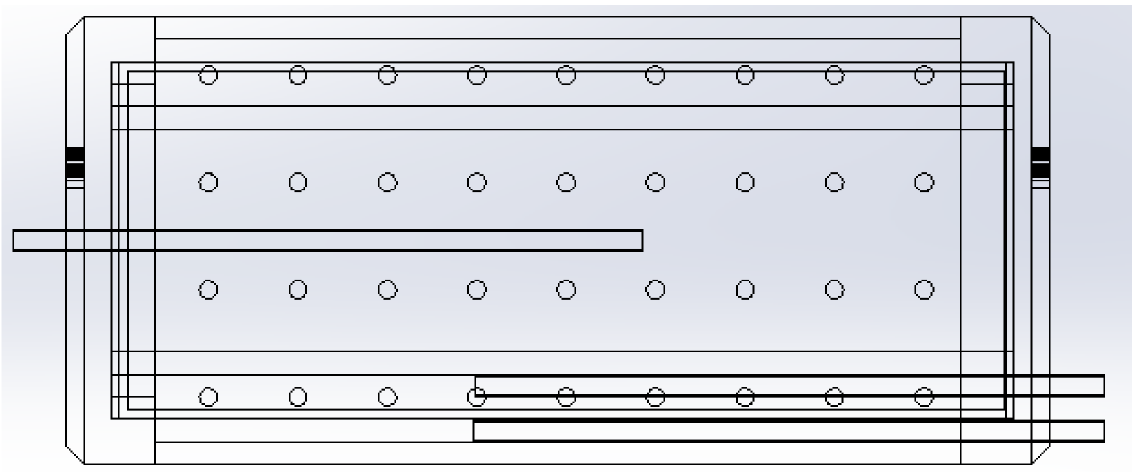

Figure 19 Wire frame View Graphene Filter

Let's in contaminated seawater into the first chamber, it sinks through the Carbon Filter Chamber, which removes a lot of the toxins, after this only salts and microbes remain in the water, we then filter to the Graphene Chamber, at this point all salts and toxins are removed, at each chamber there are waste pipes that pump out the sediments and salts to keep the filters working, natural waves also produce energy that rock the capsules which also reduces filters being blocked, it also means flexible hoses could be required if the filters not fixed with a base plate. Every so often we can reverse the pumps to blow back debris to clear filters if necessary. The pumps that operate do not need to draw on huge power and will work via a pulsing method (I am saving Pulsing technology for my master's degree) and I suggest either wave, turbine or solar with battery backup are best suited as sustainable and efficient methods.

Product Specification

Design is scaled down for prototype and material waste reasons and can be scaled up using SolidWorks.

Prototype

Table 8 Housing Chamber

Shape	Material	Diameter	Length	Weight
Hollow Cylinder	HDPE	50mm, 5mm wide	90mm	31.27 Grams

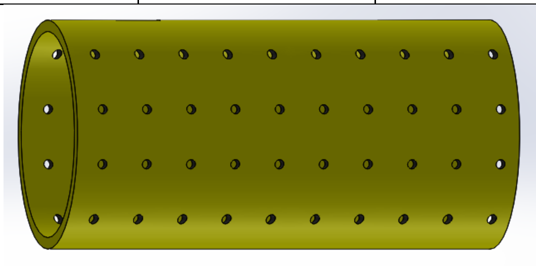

Figure 20 Housing Chamber

Table 9 Carbon Chamber (Original)

Shape	Material	Diameter	Length	Weight
Hollow Cylinder	Carbon Mesh Foam Mesh	40mm, 5mm wide	100mm	55.37 Grams

Figure 21 Carbon Chamber

Table 10 Graphene Chamber

Shape	Material	Diameter	Length	Weight
Hollow Cylinder	Graphene Oxide Membrane	30mm, 5mm wide	100mm	48.38 Grams

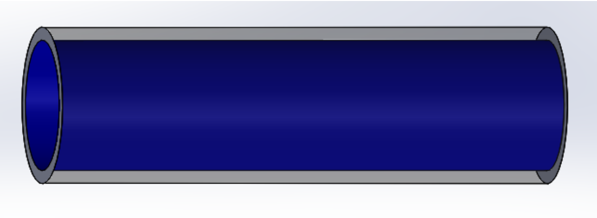

Figure 22 Graphene Chamber

Table 11 Waste Pipe

Shape	Material	Diameter	Length	Weight
Hollow Cylinder	HDPE	2.4mm, 0.5mm wide	100mm	0.9 Grams

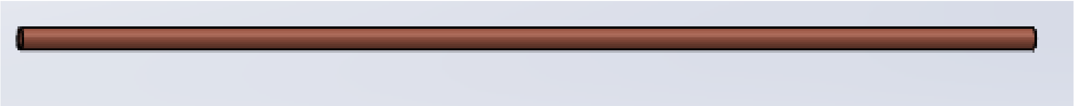

Figure 23 Waste Pipe

Table 12 Salt Pipe

Shape	Material	Diameter	Length	Weight
Hollow Cylinder	HDPE	2.4mm, 0.5mm wide	100mm	0.9 Grams

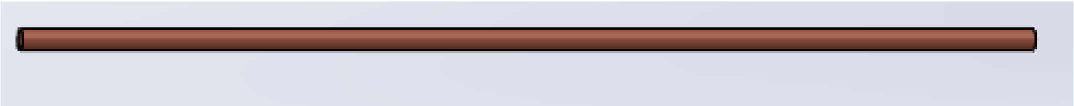

Figure 24 Salt Pipe

Table 13 Fresh Water Pipe

Shape	Material	Diameter	Length	Weight
Hollow Cylinder	HDPE	2.4mm, 0.5mm wide	100mm	0.9 Grams

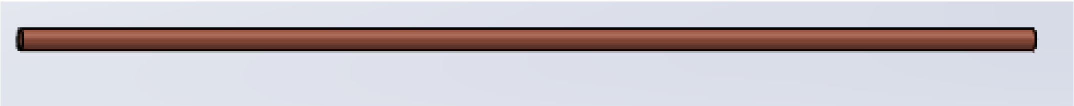

Figure 25 Fresh Water Pipe

Table 14 End Cap Fresh

Shape	Material	Diameter	Length	Weight
Spherical Cap	HDPE	50mm	10mm	15.87 Grams

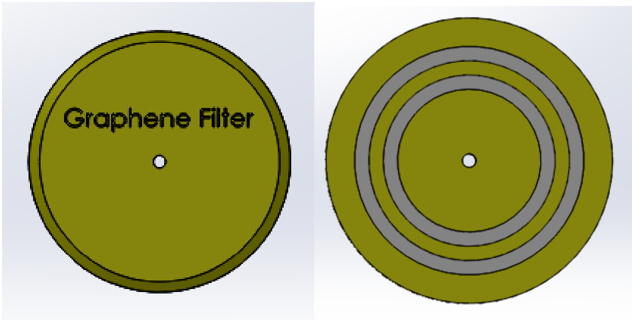

Figure 26 End Cap Fresh

Table 15 End Cap Waste

Shape	Material	Diameter	Length	Weight
Spherical Cap	HDPE	50mm	10mm	15.83 Grams

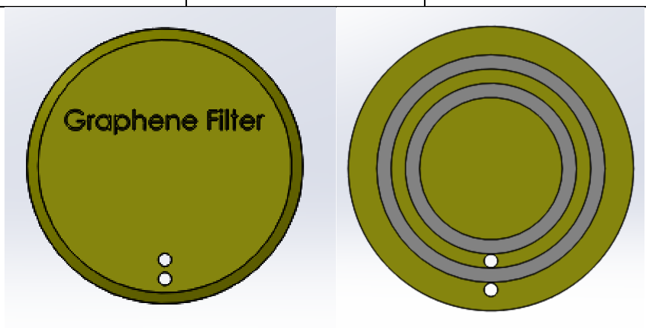

Figure 27 End Cap Waste

Both End Caps have 2x, 5mm grooves, 5mm wide, 5mm deep (extrude cut) for filters to sink into, and 4 extrude boss 2mm guides for alignment with housing.

Table 16 Overall Design weight and Dimensions

Filter Weight	Diameter	Length
169.42 Grams	50mm	110mm

Amended Specification

Table 17 Carbon Chamber

Shape	Material	Diameter	Length	Weight
Hollow Cylinder	Carbon Mesh, Filled with Carbon Pellets	40mm, 5mm wide, 1mm walls (hollow)	100mm	Mesh = 23.6 Grams Pellets = 100 Grams

Figure 28 Carbon Chamber

Table 18 Buoyancy Aid

Shape	Material	Height	Width	Length	Weight
Rectangle	Polyurethane Foam	2mm	3.5mm	100mm	0.16 Grams

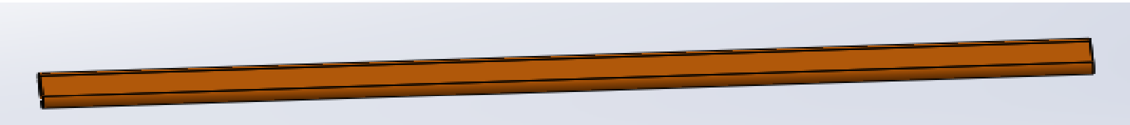

Figure 29 Buoyancy Aid

Table 19 Base Plate

Shape	Material	Width	Height	Length	Weight
Rectangle	HDPE	60mm	100mm	120mm	395 Grams

Figure 30 Base Plate

Review Design

Upon a review of my design I have a couple of issues, that I have recognised, I also would like to go over the design with clients and staff at Loughborough College to see what they think before I evolve my ideas further.

Customer Requirements

Focus Meeting

At the focus meeting I discussed the Project further with customers, clients, and staff members, the following notes were taken from the meeting.

Table 20 Focus Meeting

Question	Answer
Do you like the design?	Yes, we can see it has potential, but you should investigate the Carbon Filter for a better design.
What should I change?	Material, to reduce cost, if you can.
What should I do next?	Test the market for comparisons and competition, design a base plate, and design all in CAD.
Anything else?	Give it a name, and patent idea. Use calculations and materials for justification.
Any requirements regards to CAD?	FEA on a part to check for defects in material selection.

Focus Meeting Outcome

After a thorough meeting as to what happens next, I can now introduce my ideas, alongside what has just been said, I will amend the Carbon Filter from a foam to Carbon Pellets, now there is no conflict of interest between me and the customers, so I will introduce my further input for them to understand.

One more thing arose and that was the fact that the College are not prepared to pay for the Graphene Oxide Membrane, or the cost of the Prototype product, so I am only going to design on CAD SolidWorks and hand the files over at the end of this report.

Review Requirements (Customer)

Table 21 Carbon Chamber

Shape	Material	Diameter	Length	Weight
Hollow Cylinder	Mesh Cage, Filled with Carbon Pellets	40mm, 5mm wide, 1mm thick, hollow	100mm	Cage = 23.6 Grams Pellets = 100 Grams

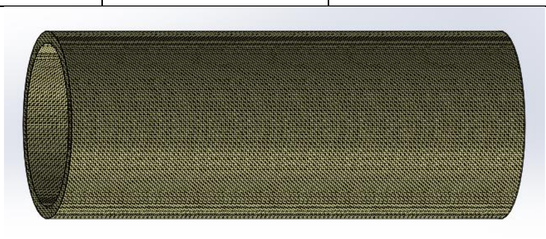

Figure 31 Carbon Chamber

Table 22 Base Plate

Shape	material	diameter	Height	Length	weight
rectangle	plastic	50mm	100mm	120mm	395.5 Grams

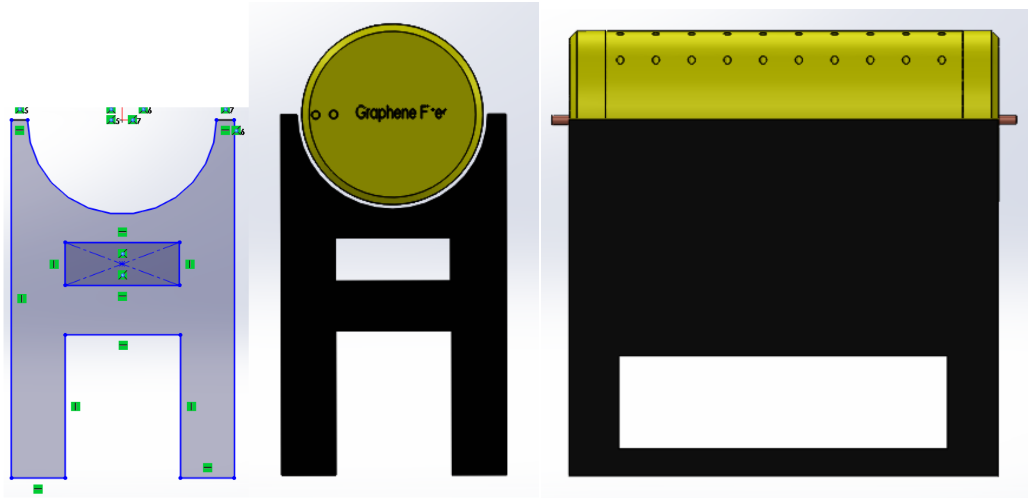

Figure 32 Base Plate

Customer requirements are complete with a change in Filter and an addition of a base plate which would serve if you fixed the filters position.

Table 23 Reviewed Overall Design weight and Dimensions

Total Weight	Filter Weight	Diameter	Length
632.65 Grams	237.65 Grams	50mm	110mm

Name

Graphene Filter

Patent

See Intellectual Property.

FEA

Finite Element Analysis will be carried out on the housing of the filter due to the calculations of prototype, the force acting over the housing is 2 Newtons, FEA will clarify if HDPE is able to cope with the force applied constantly (See FEA Section).

Further input from Design Team

Adding a buoyancy aid to the device so that it can maintain its equilibrium in the water, we want it to sit just below the surface, this then reduces pressure on the vessel and stops it from sinking and allows for a higher ratio of oil to be obtained which sits at the surface. A beacon will also be added for locational purposes to bigger designs, but not for the prototype.

Upgraded Model Parts (Design Team)

Table 24 Buoyancy Aid

Shape	Material	Height	Width	Length	Weight
Rectangle	Polyurethane Foam	2mm	3.5mm	100mm	0.16 Grams

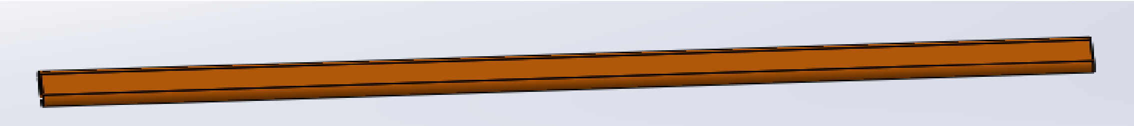

Figure 33 Buoyancy Aid

Design is complete, and Amendments have been made to the initial Product Specification. Now we will compare the product to competitors which I chose from the Current Market.

Test Market

Testing the Market means seeing what is currently available, or going to be made available, settling the differences between products, highlighting flaws and achievements, and using them to my advantage. This method helps find the pecking order where my product belongs or does not.

Competitor 1

Figure 34 Aquafilter (Sterner, 2018)

Competitor 2

Figure 35 Reverse Osmosis Water Filter (East Midlands Water, 2018)

Competitor 3

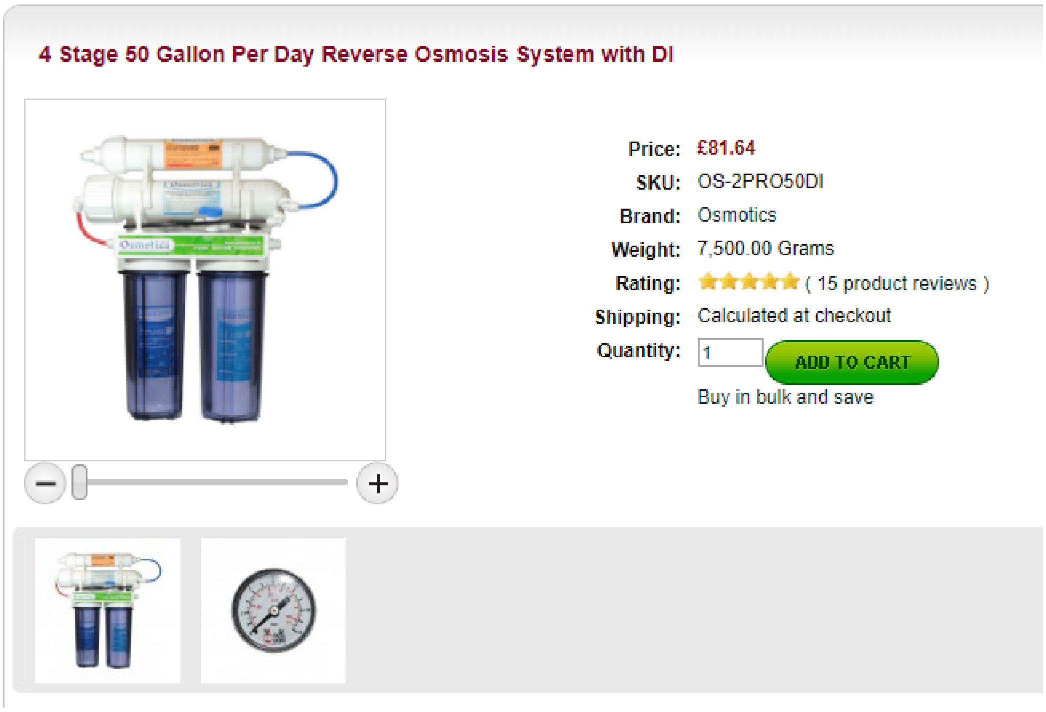

Figure 36 Reverse Osmosis System (Osmotics, 2018)

Competitor 4

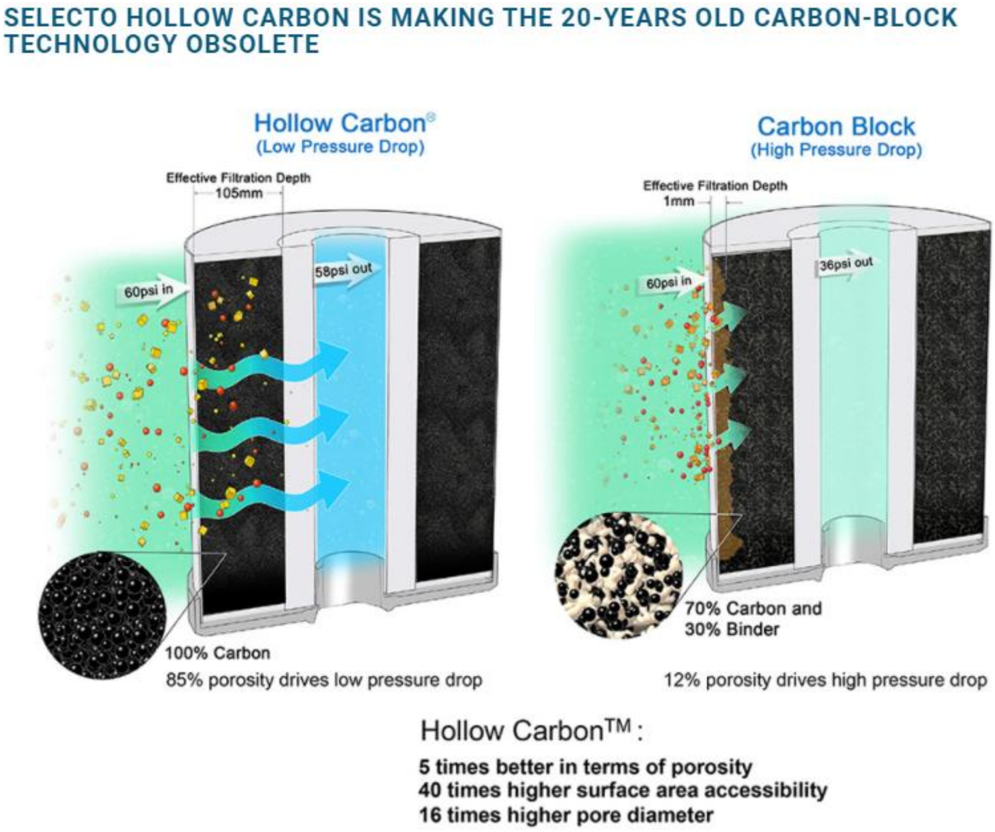

Figure 37 Hollow Carbon Filter (Selecto, 2018)

Competitor 5

Figure 38 Undersink Water Filter (Osmio Water, 2018)

House of Quality

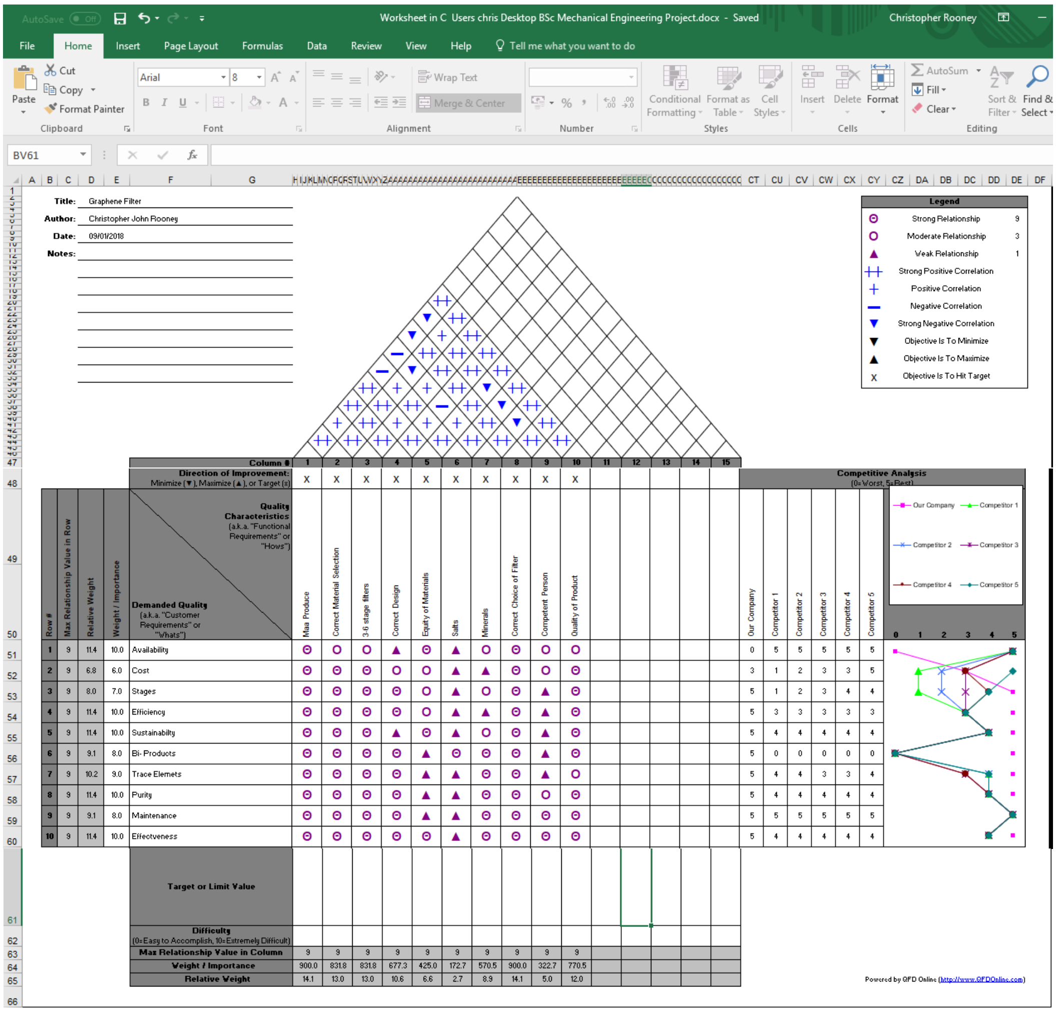

Figure 39 House of Quality

Conclusion

The House of Quality Chart compares my product against competitors and against its own criteria which details the facts in the form of a weighted balance chart that utilises component requirements and customer requirements.

There is a strong correlation between most aspects of this design, which means that it is harmonized, all information is relative, it shows how one thing can affect another, a balanced design will have a strong correlation.

Evidentially we can see that my product has an advantage over the rest in what it can achieve, it uses less steps for processing fresh water and materials, it is able to produce the by-product salt, which could be used to sell as table salt or grit by using the carbon chamber as purifier.

Introduction

The Sea Water Graphene Filter

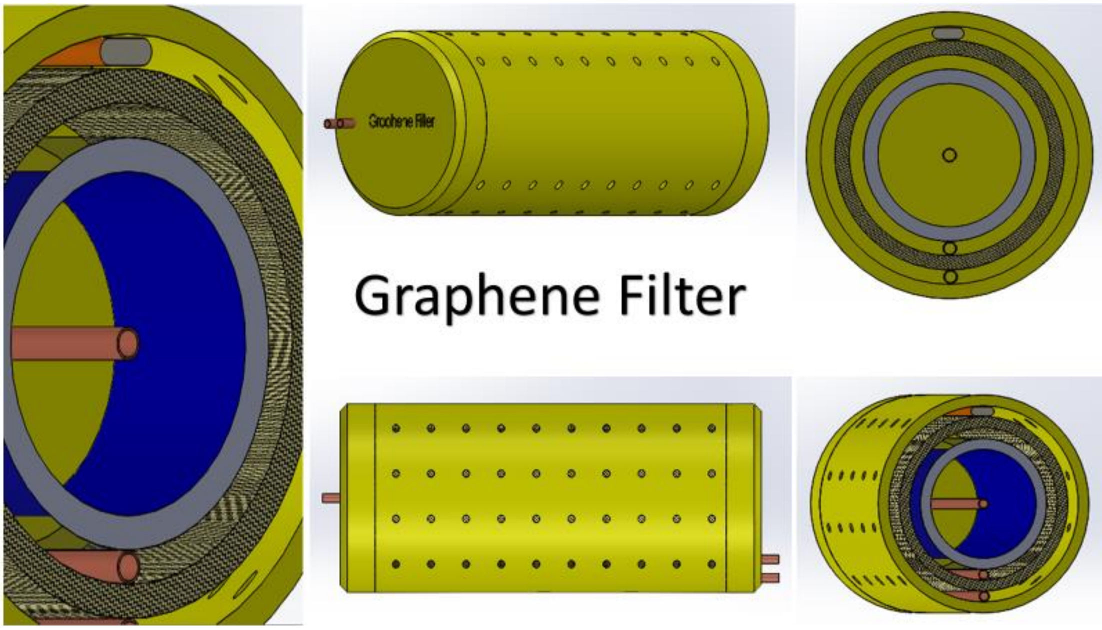

Figure 40 Poster Presentation

- Removes salts and dirt from water in 3 simple steps.
- Sustainable and Efficient.
- Investment.
- Purer method when removing salts.
- Cheaper option when compared to the current 4-6 step reverse osmosis process.
- Entitles everyone to clean water, everywhere without building infrastructure.
- Big and small installations available.
- 100% green.
- Buoyancy Aid for equilibrium.

Evaluation

To evaluate I will use a SWOT Analysis type method, this highlights strength, weaknesses, opportunities and threats, which are all relevant to the outcome of this design.

Strength

Graphene Filter is a 3-step process in obtaining fresh water from sea or dirty water, environmentally friendly, efficient and a sustainable method of providing clean water instantly, ideal for camping or long treks, in its smaller form.

on a larger scale could provide drinking water direct from the sea to the masses, easy to manufacture, cheap components, prices vary with size.

Weaknesses

I hope it does not leak, I am using waterproof resins tried and tested in marine environments to seal the joints rather than welds and nuts and bolts, Resins can protrude into areas welds Cannot, the vessel must be waterproof and water ready, all at the same time.

Opportunities

This device could be used in many applications, it is not just limited to sea water, but is most effective in that environment, the aim is to provide drinking water to everyone everywhere, at any time.

Threats

People that I am unaware of may have undertaken this idea, which I have no control over or knowledge I started this project 9 months previous, and in that time people may be considering Graphene for filter uses, however none of the filters are manufactured using Graphene Oxide Membrane, if it looks like my Device, then I have been plagiarised, at this point I would approach who it may concern and have a formal discussion before I take matters further.

Alternatively, and probably the best option would be to send my work to a patent service provider who do all the chasing for me. All I must do is ask for an information pack which they will send to fill out, send it back and they will contact regards to the idea, and how viable it is.

Prototype Cost

Table 25 Cost of Machinery (rented)

CNC Machine	£20
Injection Moulding	£20
Manual Tools	£10
Packaging	£3

Table 26 Cost of Materials (bought)

Plastic	£5
Carbon	£25
Graphene	£150
Resin	£20

Table 27 Cost of Production

Staff	£0
Materials	£200
Machinery	£53
R & D	£5
Marketing	£50

Cost of Prototype

£308 to produce a prototype, with extra material allowances.

Materials

High Density Polyethylene

(**HDPE**) (Case, Caps and Pipes)

Figure 41 (HDPE) (Case, Caps and Pipes) (IndiaMart, 2018)

Figure 42 HDPE Drum (IndiaMart, 2018 (2))

High-density polyethylene (HDPE) is a polyethylene thermoplastic and is made from petroleum. Sometimes it is called polythene or alkathene when used for pipes.

Applications

- Chemical Drums
- Jerrycan's

- Carboys
- Toys
- Picnic Ware
- Household and Kitchenware
- Cable Insulation
- Carrier Bags
- Food Wrapping Material

Properties

- Flexible
- Translucent/Waxy
- Weatherproof
- Excellent Low Temperature Toughness (To -60'C)
- Easy to Process
- Low Cost
- Good Chemical Resistance

Physical Properties

- Notched impact strength no break Kj/m^2
- Thermal coefficient of expansion 100 – 220 x 10-6
- Max continuous use temperature 65℃
- Density 0.944 – 0.965 g/cm^3
- Tensile strength = 0.20 – 0.40 N/mm^2

Resistance to Chemicals

- Dilute Acid
- Dilute Alkalis
- Oils and Grease
- Aliphatic Hydrocarbons
- Aromatic Hydrocarbons
- Halogenated Hydrocarbons
- Alcohols (British Plastics Federation, 2018)

Structure

Ethylene (C_2H_4) is a gaseous hydrocarbon it is commonly produced by cracking ethane, Ethylene molecules are made of two methylene units (CH_2) they are linked together by a double bond between the carbon atoms, a structure represented by the formula $CH_2=CH_2$. Under the influence of polymerization catalysts, the double bond can be broken, and the resultant extra single bond is then used to link to a carbon atom in another ethylene molecule (Encyclopaedia Britannica, 2018).

The structure is repeated over thousands of times in a single molecule, this is the key properties of polyethylene. The long, chainlike molecules, to which hydrogen atoms are connected to a carbon backbone, these can be produced in branched forms or linear. linear versions are known as high-density polyethylene (HDPE) the branched versions are also known as low-density polyethylene (LDPE) The basic polyethylene composition can be modified by the inclusion of other elements or chemical groups (Encyclopaedia Britannica, 2018).

Carbon

The atoms of carbon can be bonded together in different ways, these are termed as the allotropes of carbon. The most famous is diamond, graphite and amorphous carbon. Physical properties of carbon vary a lot with the allotropic form.

About

Carbon is exceptional among the elements in its capability to form strongly bonded chains, there are sealed off by the hydrogen atoms. Hydrocarbons are mined naturally as fossil fuels such as natural gas oil and coal. These are common fuel types. Impure carbon in the form is used in metal smelting. And is very important in the iron and steel industries.

Uses

Graphite is used in furnace linings, pencils, and brushes on electrical motors. Activated charcoal is used for filtration purification. It is found in respirators and kitchen extractor hoods (Royal Society of Chemistry, 2017).

Activated carbon filters

Carbon is active in the process of removing organic compounds and extracting chlorine from water, it can remove almost all pollutants in water. Eliminating humic and fulvic acid which prevents chlorine in the water from chemically reacting with the acids and forming trihalomethanes, a class of known carcinogens. It does not remove microbes, sodium, fluoride, and nitrates (Water Professionals, 2018).

Structure

Simple organic compounds comprise molecules composed of carbon and hydrogen. For example, methane contains one carbon bonded to four hydrogens. Ethane is another example of a simple hydrocarbon.

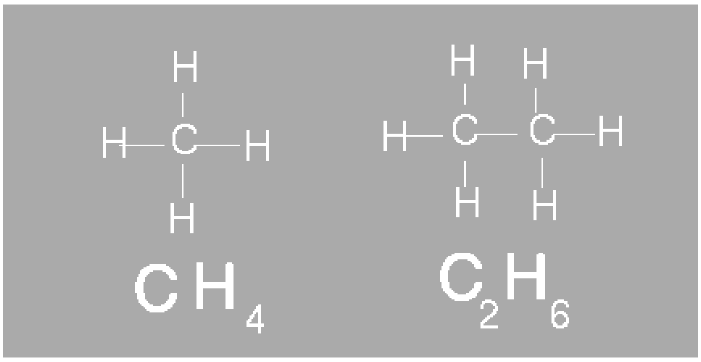

Figure 43 Hydrocarbon (EdInformatics, 1999)

Graphene

Graphene is a single atomic layer of graphite, an abundant mineral which is an allotrope of carbon which is made up of very tightly bonded carbon atoms, they are arranged into a hexagonal lattice. Graphene is unique it has a very thin atomic thickness (of 0.345Nm). These properties enable graphene to break so many records in terms of electricity strength, and heat conduction.

Monolayer graphene was isolated in 2004, beforehand it was assumed that two dimensional compounds could not exist due to the thermal instability once separated. Once graphene was isolated, it became clear that it was a reality. Once the suspended graphene sheets were studied by transmission electron microscopy, it was thought that the reason was due to slight rippling in the graphene, which modified the structure of the graphene. But the latest research suggests that since the carbon to carbon bonds in graphene are so small and strong, it prevents thermal fluctuations from destabilizing it.

Graphene Due to its strength of 0.142 Nm-long its carbon bonds make the material the strongest ever discovered, with an ultimate tensile strength of 130,000,000,000 Newtons. Not only is graphene extraordinarily strong, it is also super light at 0.77milligrams per square metre. If a single sheet of graphene, sufficient in size was to cover Leicester city's football clubs pitch it would weigh less than a single gram.

It also contains elastic properties, which allows it to retain its initial size after strain. Graphene that contains no imperfections whatsoever is currently very expensive and difficult to artificially reproduce, however, production techniques are steadily improving, which will reduce the price.

Properties of Graphene Oxide

Graphene oxide has easy dispensability in water and with other organic solvents, as well as different types of matrixes, this is because of the presence of the oxygen functionalities. This is a very important property when it is mixed with material with polymer or ceramic matrixes when trying to improve their electrical and mechanical properties.

In terms of electrical conductivity, graphene oxide acts as an electrical insulator, due to sp2 bonding network disruption. To recover the honeycomb hexagonal lattice, alongside the electrical conductivity reduction of the graphene oxide must be achieved. It is assumed that once most of the oxygen groups are detached, the reduced graphene oxide obtained is difficult to disperse because of its tendency to create aggregates.

When graphene oxide is usable as an intermediary by creating monolayer or few layer graphene sheets, it needs an oxidization and reduction process that will separate the individual carbon layers and isolate them without changing structure. Currently the chemical reduction of graphene oxide is seen as the most suitable way of mass production of graphene, In the past it has been difficult for professionals to produce graphene sheets the same quality as mechanical exfoliation for example, once we achieve the above graphene will be produced on a much bigger scale (Graphena, 2018).

Structure of Graphene

Graphite is the material in a pencils lead, and it's made up of sheets of graphene which are stacked together. Sheets of graphene in graphite have a space between each sheet and the sheets are held together by the electrostatic force called van der Waals bonding.

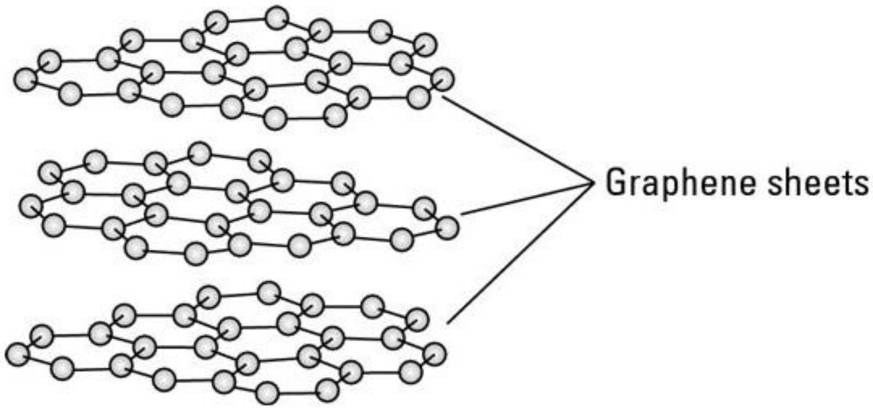

Figure 44 Graphene Sheets (Boysen, et al., 2018)

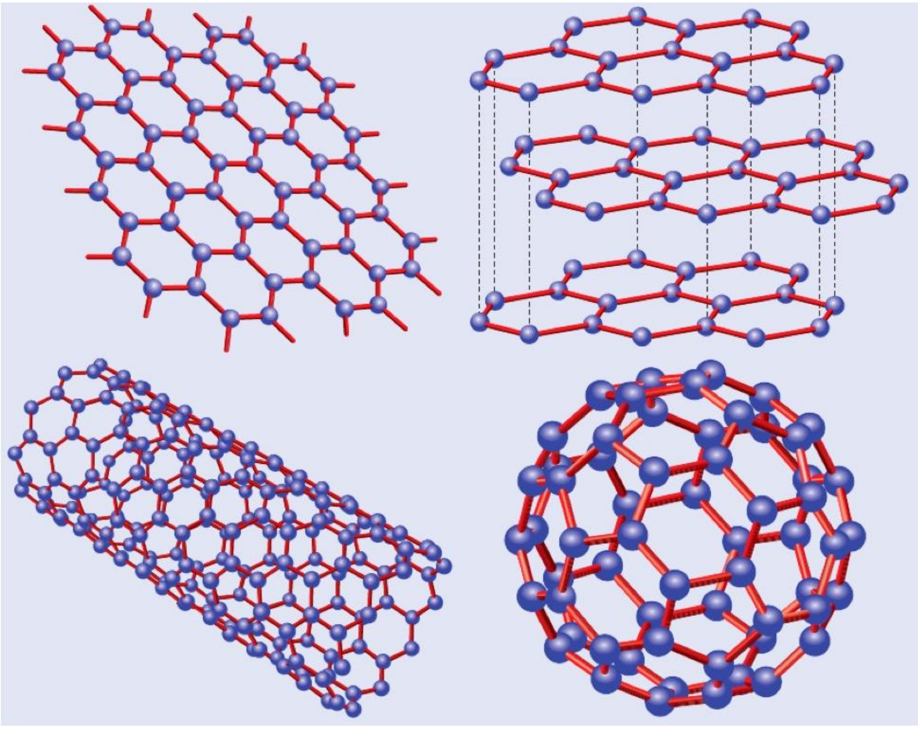

Figure 45 Unit Cell for Graphene (Stack Exchange, 2017)

Methodology

To take sheets of Graphene Oxide Membrane and layer them together, wrap it around the inner chamber casing and use the Bostick resin to seal it so no leaks occur.

Foam

Low Density Polyethylene (LDPE)

Figure 46 Low Density Polyethylene (LDPE) (India Mart, 2018)

Polyethylene Foam

A resilient material, it is durable, lightweight closed cell material. Commonly used as packaging for fragile goods because of its ability to handle vibration and insulation properties. Other properties include high resistance to chemicals and moisture. Polyethylene foam is very easy to fabricate and process. And in this case is used as a buoyancy aid.

Polyethylene Foam Material Characteristics

- Closed-Cell
- Very lightweight
- Non-abrasive
- Easy to fabricate
- Non-Dusting
- Superb strength and tear resistance
- Excellent shock absorption & vibration dampening properties
- Flexibility
- Impervious to mildew, mould, rot, and bacteria
- Resistant to water, chemicals, solvents & grease
- CFC free
- Odourless
- Excellent buoyancy
- Very cost-effective
- Excellent thermal insulation properties (UFP Technologies, 2018)

Structure of Polyurethane Foam

Polyurethane urethane group

-NH-(C=O)-O-

link the molecular units.

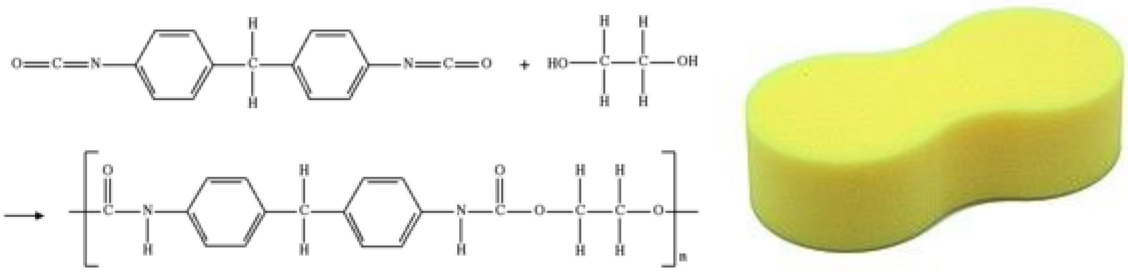

Figure 47 Polyurethane Foam (UFP Technologies, 2018)

Resin

Bostik Thermogrip® H9389

As regards to the graphene filter Bostik Resin bonds the filters to the caps and is used on outside joints that are then heat shrunk using a rubber shroud. Bostik is a waterproof tough sealant, used for Double glazed windows, it has multiple purposes and is hot melted to fill joint.

KEY FEATURES

- Excellent heat resistance
- Very good hot tack
- Long open time

DESCRIPTION

H9389 is a hot melt adhesive for assembly applications, including pleat separation for air filters. It has a long open time, very good hot tack, and high melting point. Excellent adhesion to a variety of substrates including many plastics, metal and paper.

PACKAGING

For packaging options please call your Bostik sales or technical representative.

SHELF LIFE

Can be stored 730 days in a clean dry place, in its original package at an average temperature of 25°C or below. Storage temperature should not exceed 40°C.

STORAGE & HANDLING

Wear safety gloves and goggles when handling molten adhesive to minimize the risk of burns.

COUNTRY OF MANUFACTURE

United States

APPLICATION TECHNIQUES

Bead or slot extrusion

CLEANUP PROCEDURE

Mineral oil or paraffin wax are recommended for cleanup but should not be used at temperatures that exceed the flash point as stated on the SDS. This procedure should be followed by a thorough purge with the adhesive.

TYPICAL PHYSICAL PROPERTIES

Description	Results
Thermosel Viscosity (Brookfield - ASTM D3236)	35,000 cP @ 350°F 25,000 cP @ 375°F 17,500 cP @ 400°F
Softening Point (Ring and Ball Herzog - ASTM E28)	315°F
Suggested Running Temperature	350 - 400°F
Density	0.92 g/cc @ 77°F

Figure 48 Bostik Properties (Bostik, 2018)

Bostik Thermogrip® H9389 is a hot melt adhesive and is designed for a variety of assembly applications mainly connecting double glazed units to spacer bars. It has strong adhesion properties which include paper, metal and plastics, making it ideal for use in pleat separation for air filters and other applications. It's very good at hot tacking and has excellent heat resistance (Bostik, 2018).

Calculations (prototype)

A Graphene Filter is to be used in sea water to produce Fresh Water, (p = 1027 kg/m^3). The filter housing is 50mm in diameter and 100 mm long. It has an overall length/height of 110m, Calculate the Volume, the hydrostatic pressure on the Filter and the weight of the Filter in Newtons.

Table 28 Facts - Prototype

Total Weight	Filter Weight	Diameter	Length
632.65 Grams	237.65 Grams	50mm	110mm

Table 29 Symbols & Values

PE = pgh
rho = Density of Salt Water = 1027kg
pa = Pascals
N = Newton
V = Volume
g = 9.81 gravity
h/L = 0.11m overall
D/W = 50mm
r = 25mm
Fb = Buoyant Force
F = Force
P = Pressure
Pa, Kpa, Mpa = pressure or force

Volume of Filter

$$\boldsymbol{v} = \pi r^2 h$$

$$\boldsymbol{v} = \pi \text{ x } 0.0252 \text{ x } 0.1 \ = \ 196.35\text{x}10^{-4}$$

$$\boldsymbol{v} = 196.35x10^{-4}$$

Hydrostatic Pressure

$$p = pgh$$

$$p = rho = density\ of\ salt\ water = 1027kg$$

$g = 9.81$

$h = \ 0.11m\ (Includes\ End\ Caps)$

$1027x9.81x0.11 = 1108.2357pa$

$Hydrostatic\ Pressure = 1108.2357pa$

Force over the Graphene Filter Prototype

$Fb = Vpg$

$196.35x10^{-4}x1027x9.81 = 1.978196099N$

$Fb = 2N$

Force

$F = PA = \frac{\pi D^2}{4}$

$$2x\frac{\pi x0.050^2}{4} = 3.92$$

$F = 3.92x10^{-3}$

Force trying to split Vessel

$F = PA = PLD$

$1.92x0.1x0.050 = 9.6x10^{-3}$

$F = 9.6x10^{-3}$

Stress and strain on housing

Yield Strength	2.62e7 - 3.1e7	Pa
Tensile Strength	2.21e7 - 3.1e7	Pa
Elongation	11.2 - 12.9	% strain
Hardness (Vickers)	7.75e7 - 9.71e7	Pa
Impact Strength (unnotched)	1.9e5 - 2e5	J/m^2
Fracture Toughness	1.52e6 - 1.82e6	Pa/m^0.5
Young's Modulus	1.07e9 - 1.09e9	Pa

Figure 49 HDPE Properties

$\mathbf{Yield\ Strain\ for\ HDPE}\ =\ 0.2\%\ \text{original length}$

$$\varepsilon = L - L_O/L_O$$
$$\varepsilon = 100.2 - 100/100$$
$$\varepsilon = 99.2mm$$

Stress (Tensile Strength)

$$\sigma = E\varepsilon$$
$$\sigma = 31x10^7\ x\ 99.2 = 307520000$$
$$\sigma = 307520000\ pa$$

Yield Strain

$$D =\ 0.2\%\ 0f\ 50mm\ =\ 0.1mm$$

$$0.1x10^{-3} = 1x10^{-4}$$

$$L_0 = 100mm\ =\ 0.1x10^{-3}$$

$$y = \frac{D}{L_0} = \frac{1x10^{-4}}{0.1x10^{-3}} = 1$$

meaning the graph will be a straight line until it yeilds.
Stress and strain are equal.

$$\mathbf{t = Gy}$$

$$307520000\ \ x\ 1 = 307520000\ (Tensile\ strength)$$

Stress / Strain Ratio

$$\frac{stress}{strain} = \frac{307520000}{307520000} = 1$$

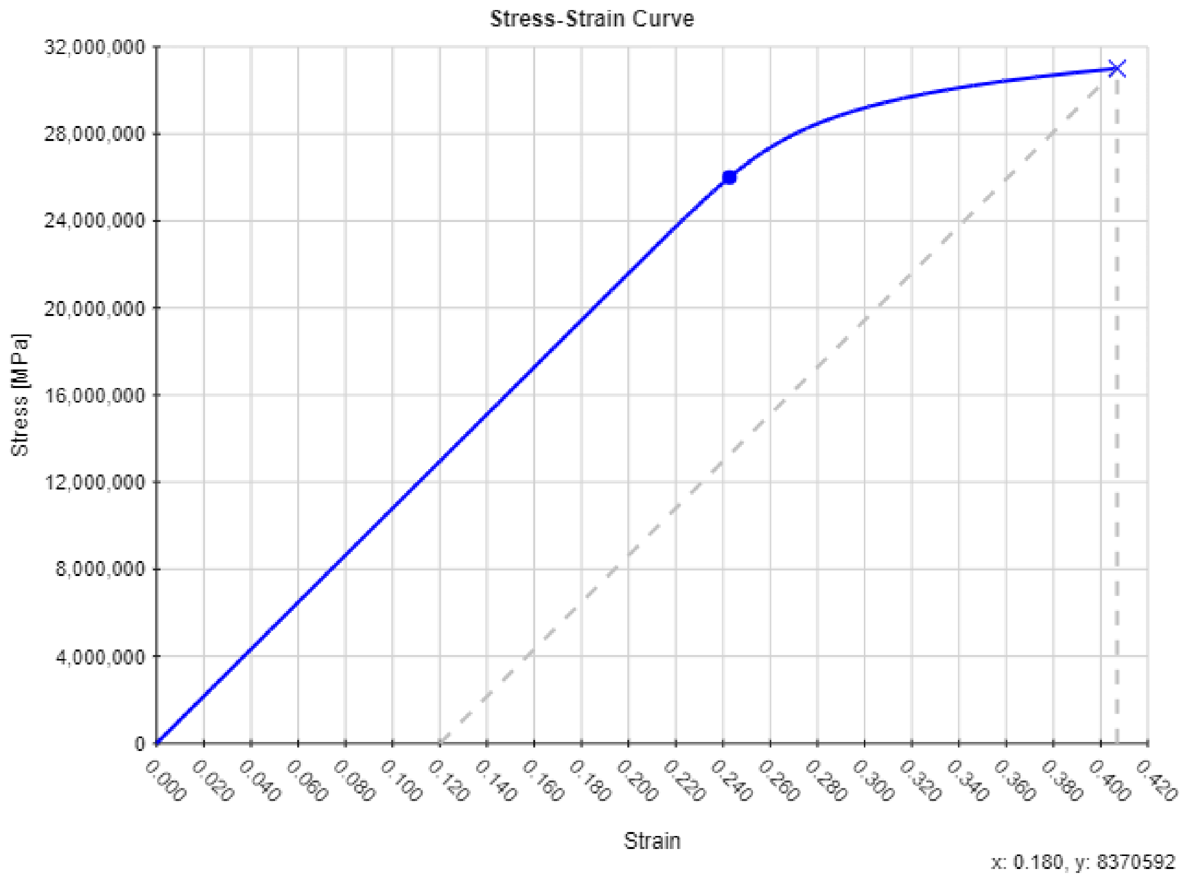

Figure 50 Stress Over Strain Curve

Results

Stress over strain results match those selected from given data, give or take dimensions of housing, it will always adjust values slightly. Strength of material is more than ample to withstand pressures and forces, almost overkill but it's the properties such as Acids and Alkalis it is good at resisting which exist in fresh and sea water.

Wave Height, and speed (Hypothetical Wave Force)

Assume filter is 1.1m in length (10 x prototype dimensions)

$Velocity = 5ms$
$Wavelegth = 10m$
$Frequency\ and\ wave\ period\ calculations$

$$F = \frac{v}{\lambda}$$

$$T = \frac{1}{\mathrm{F}}$$

Substitute Formula

$F = \frac{5}{10} = 0.5\ H_z$

$T = \frac{1}{0.5} = 2\ seconds$

$Frequency = 0.5H_z(Amplitude)$

$period\ of\ waves = 2\ seconds$

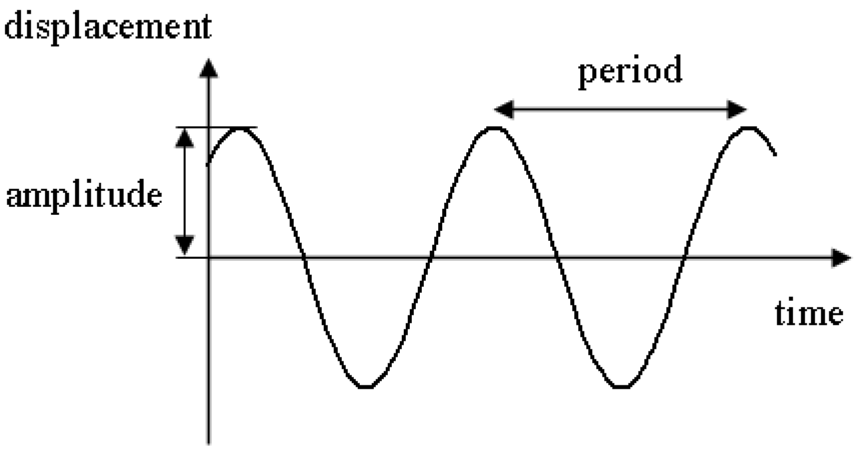

Figure 51 Period and Frequency Graph (Wikibooks, 2017)

Result

With a wave period of 2 seconds and a flowrate at 5m/s and frequency of 0.5 H_z the filter rides the waves which helps reduce wear and tear. Very important if the Vessel was put out to sea. Further calculations rely on flowrate and FEA is required which is the next step, however that is at master's level and I do not have the facilities to carry it out over the graphene and carbon chambers.

Assembly

Assembly in Real life will be held together with resins as oppose to bolts for erosion reasons, and it helps give a better seal all-round, if you can imagine that when the parts are mated there is a Bostik Glue on each part connected to another part which gives strength. Mates in this design are all Concentric because of the cylindrical Russian doll design, below is a method of how to Build the Device.

Step 1

Import fresh water end cap into SolidWorks

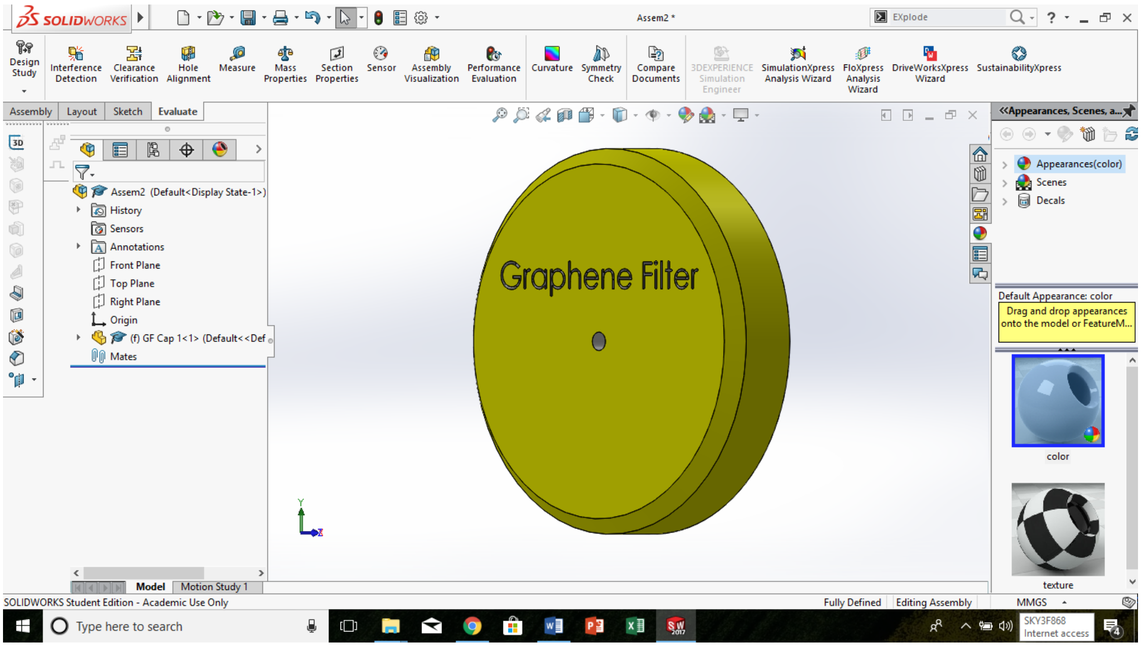

Figure 52 SolidWorks Fresh Water Cap

Step 2

Import Graphene Filter and mate Concentric with Extrude cut 5mm deep centre.

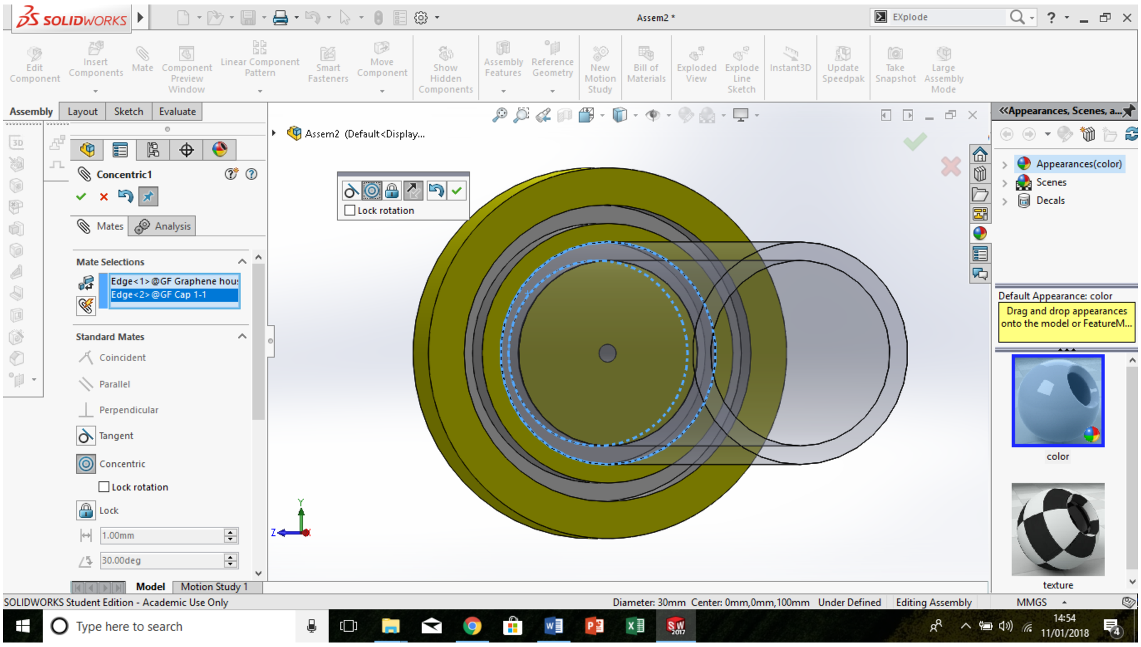

Figure 53 SolidWorks Graphene Mate

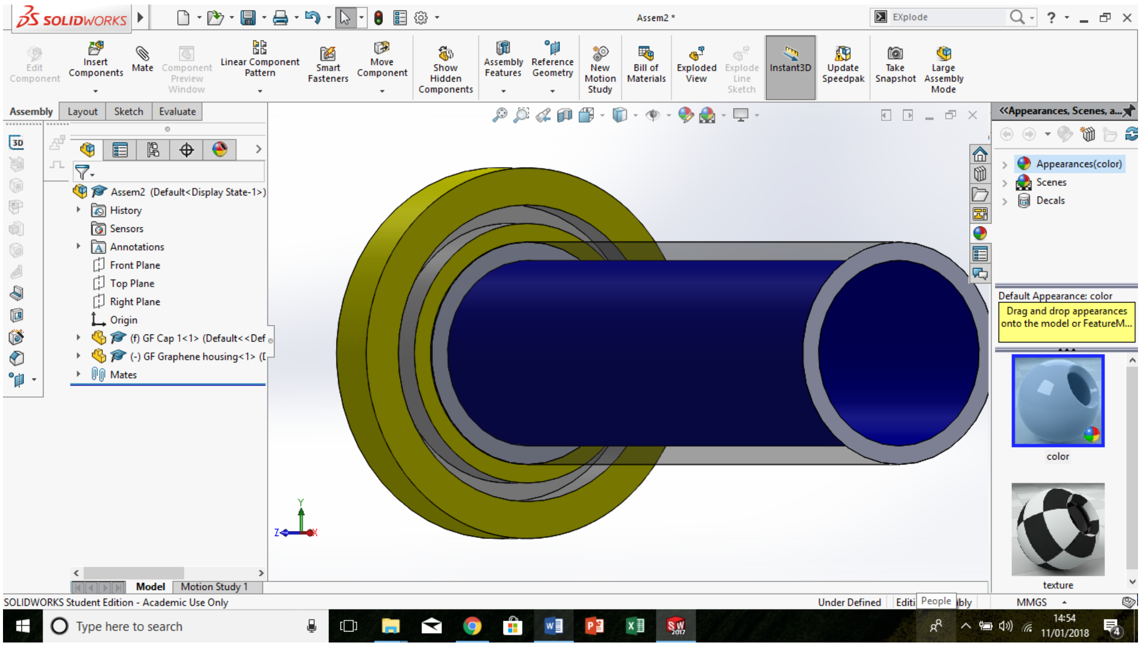

Figure 54 SolidWorks Graphene Mate

Step 3

Import Carbon Filter, same process as before.

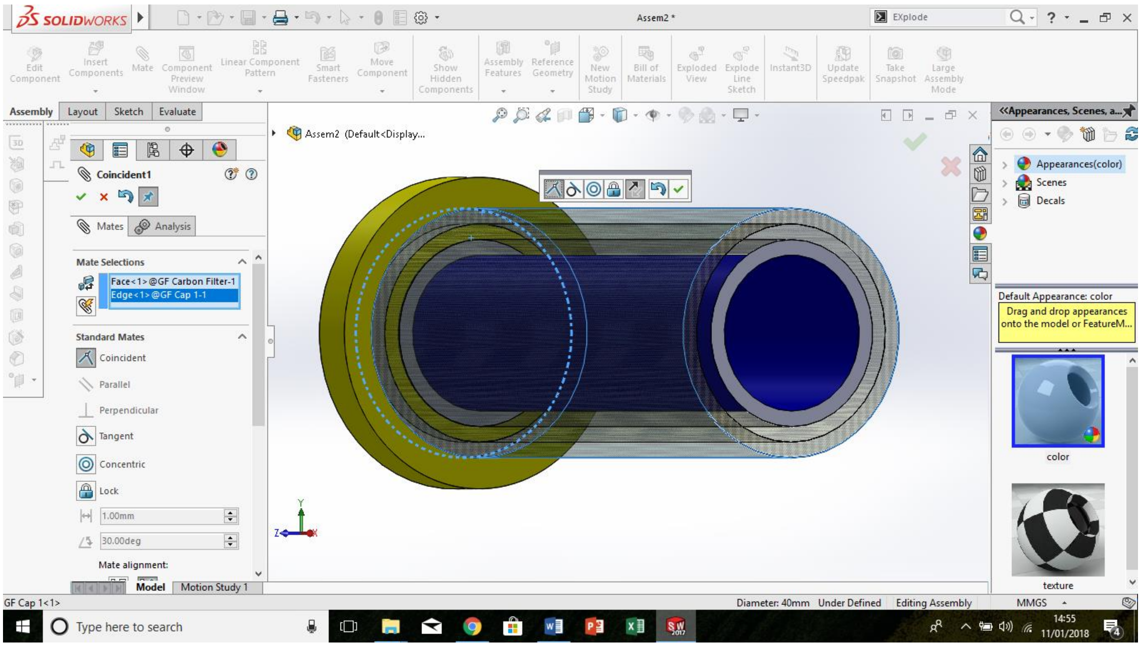

Figure 55 SolidWorks Carbon Mate

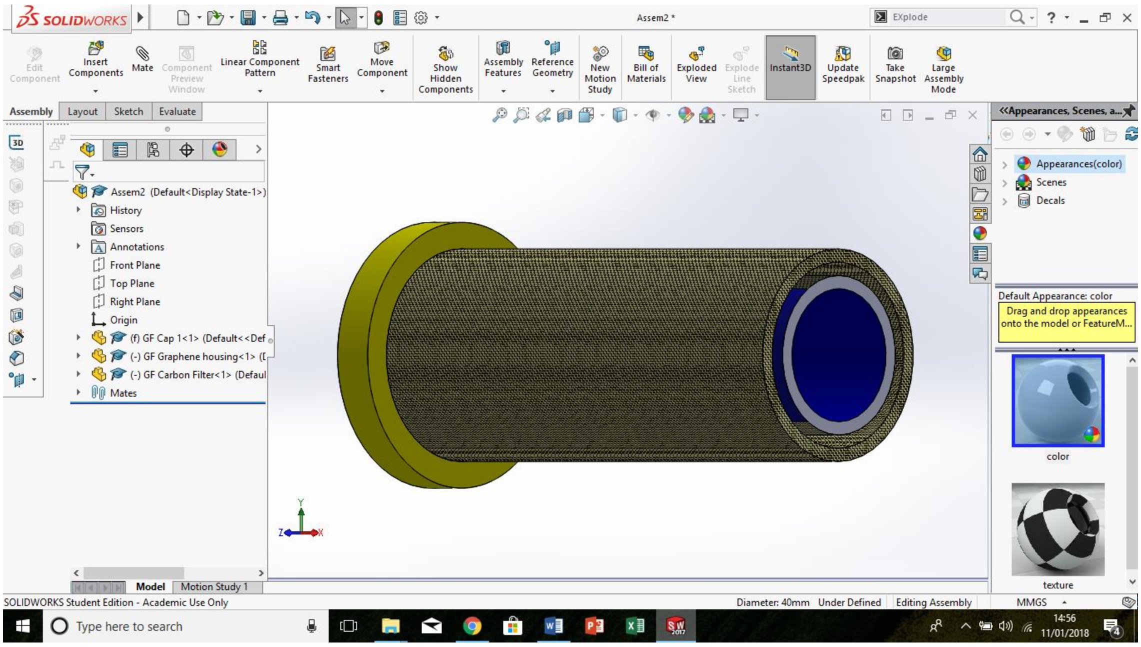

Figure 56 SolidWorks Carbon Mate

Step 4

Import Fresh Water Pipe, Position in centre hole.

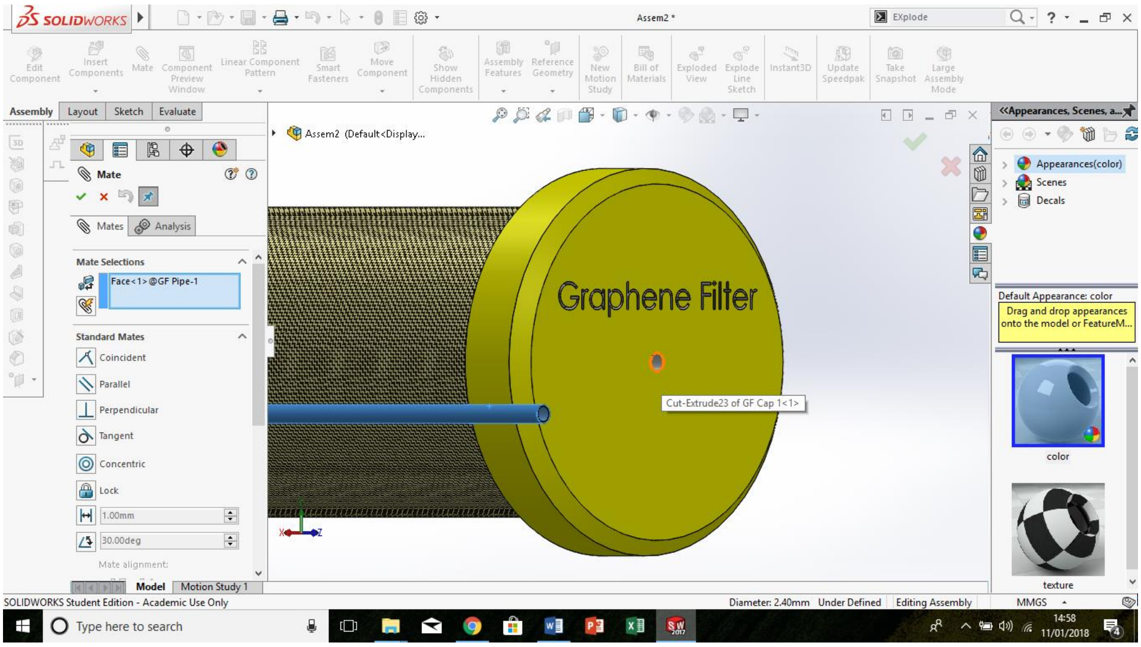

Figure 57 SolidWorks Fresh Water Pipe Mate

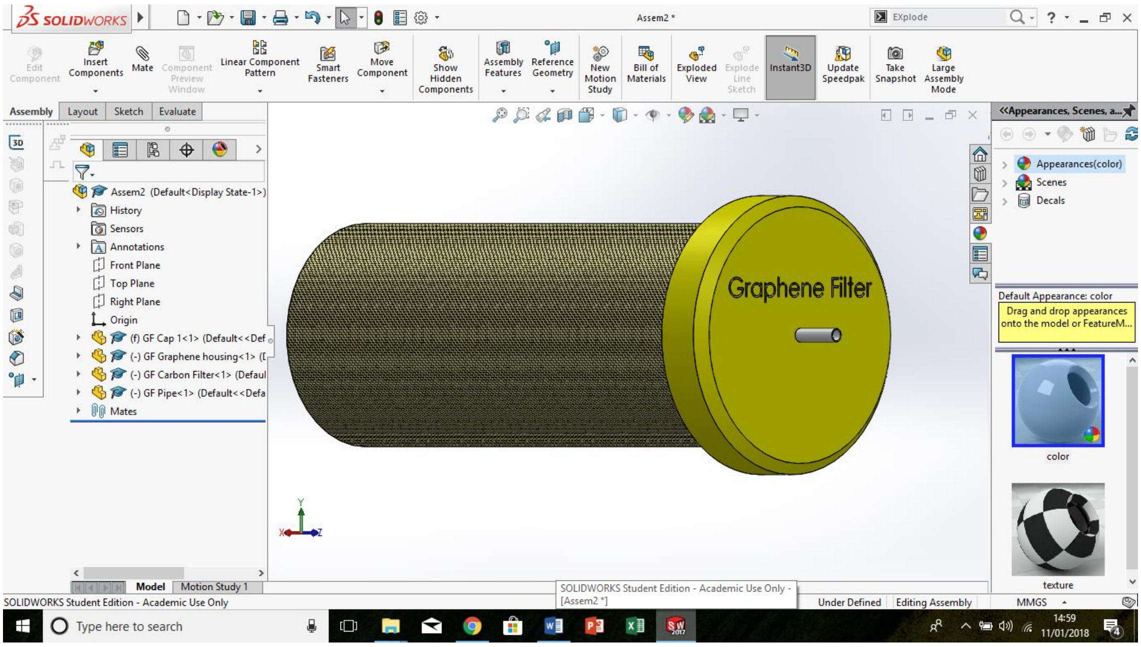

Figure 58 SolidWorks Fresh Water Pipe Mate

Step 5

Import exterior casing, concentric mate for accuracy and alignment of filters.

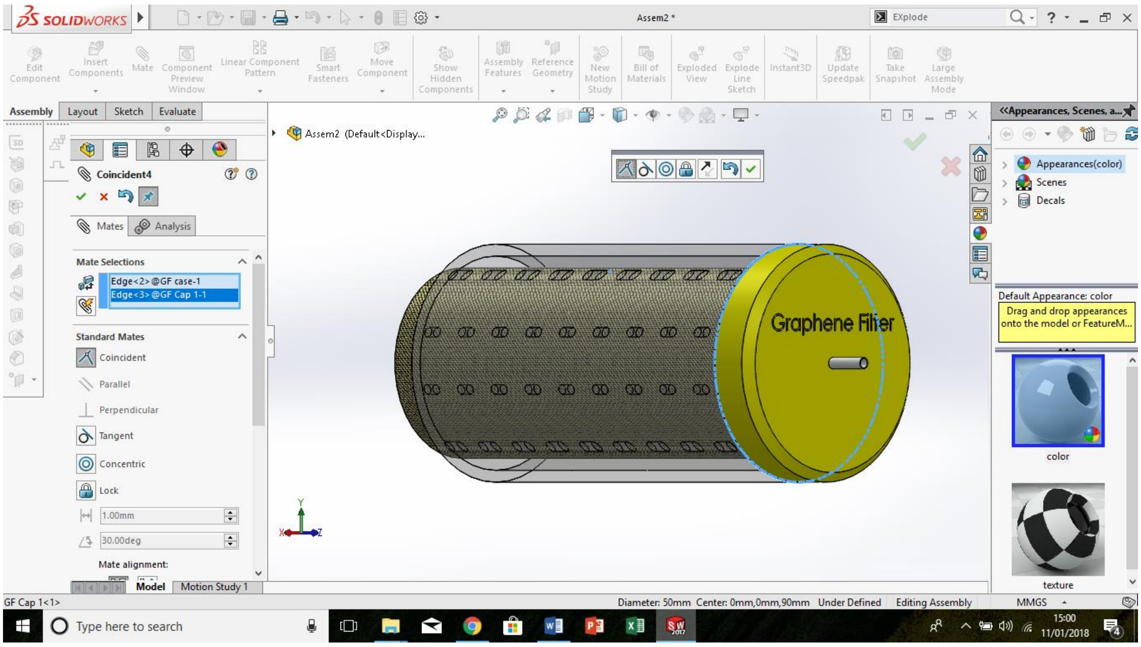

Figure 59 SolidWorks Fresh Water Pipe Mate

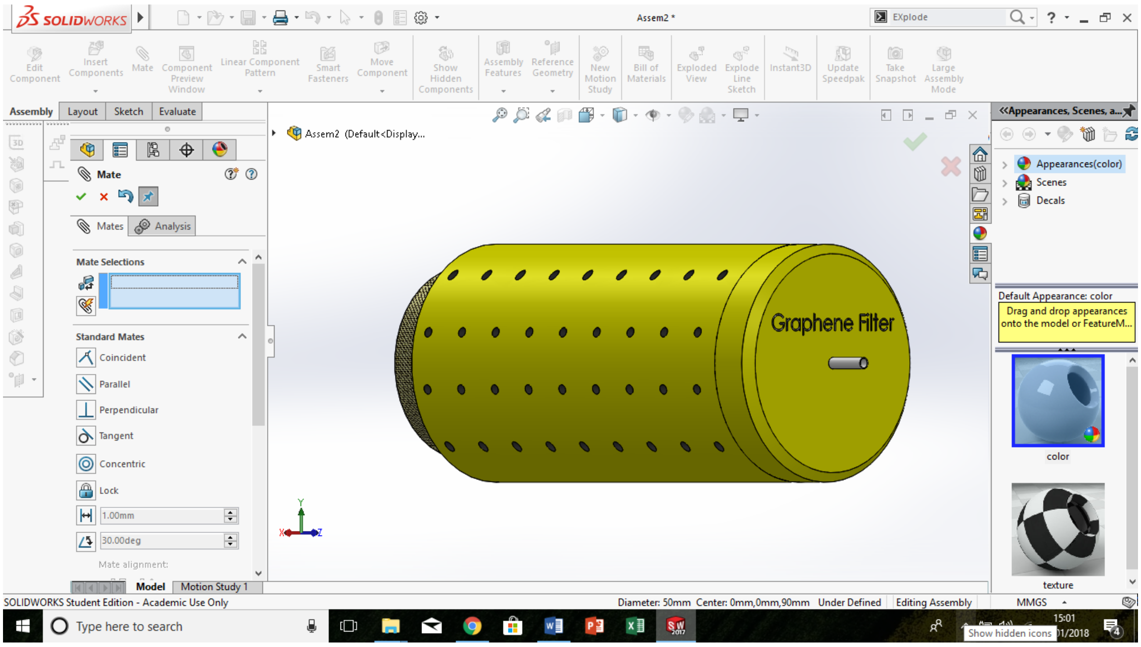

Figure 60 SolidWorks Fresh Water Pipe Mate

Step 6

Import Dirty and Salt Cap and concentric mate to the casing for alignment of filters.

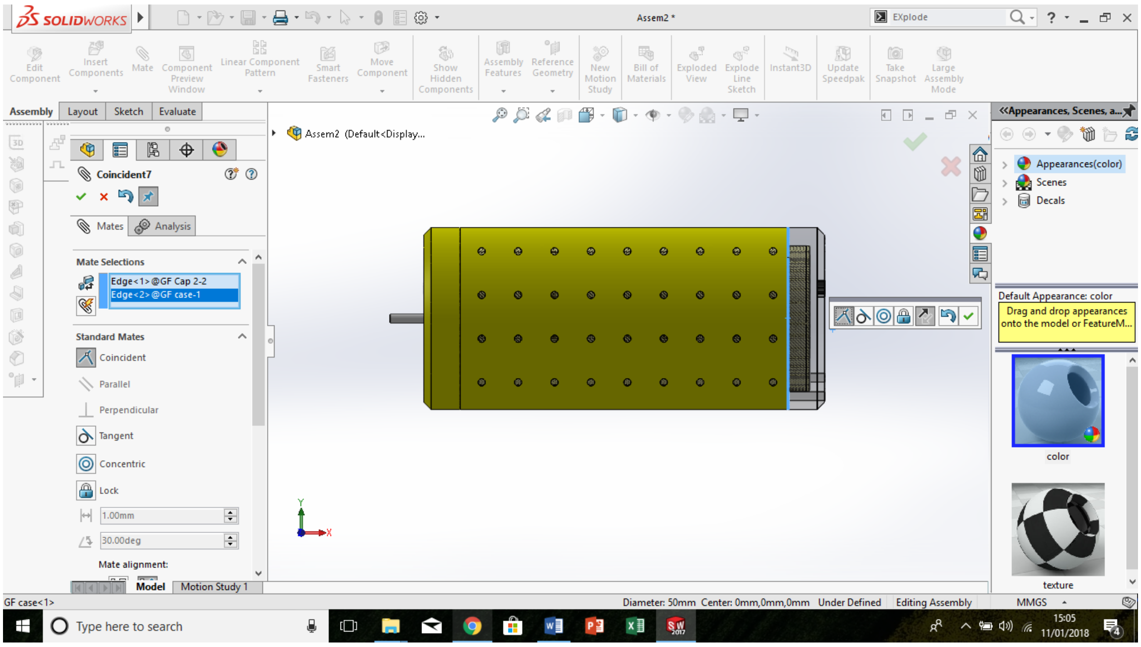

Figure 61 SolidWorks Waste End Cap

Step 7

Import Dirty and Salt Pipes.

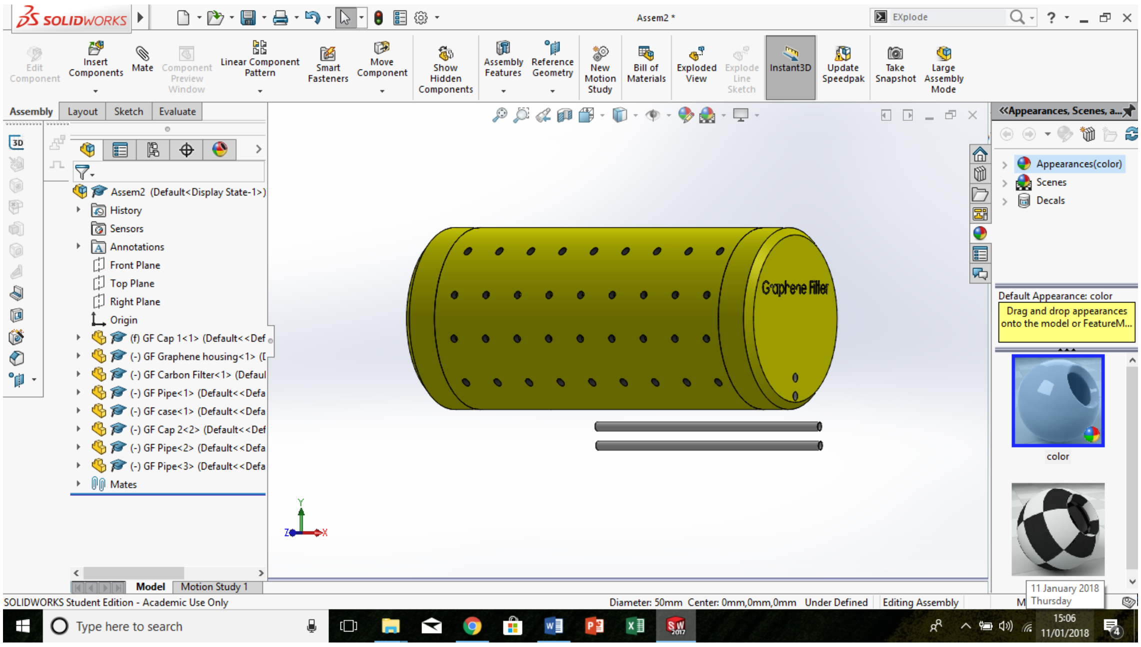

Figure 62 SolidWorks Waste Pipe Mate

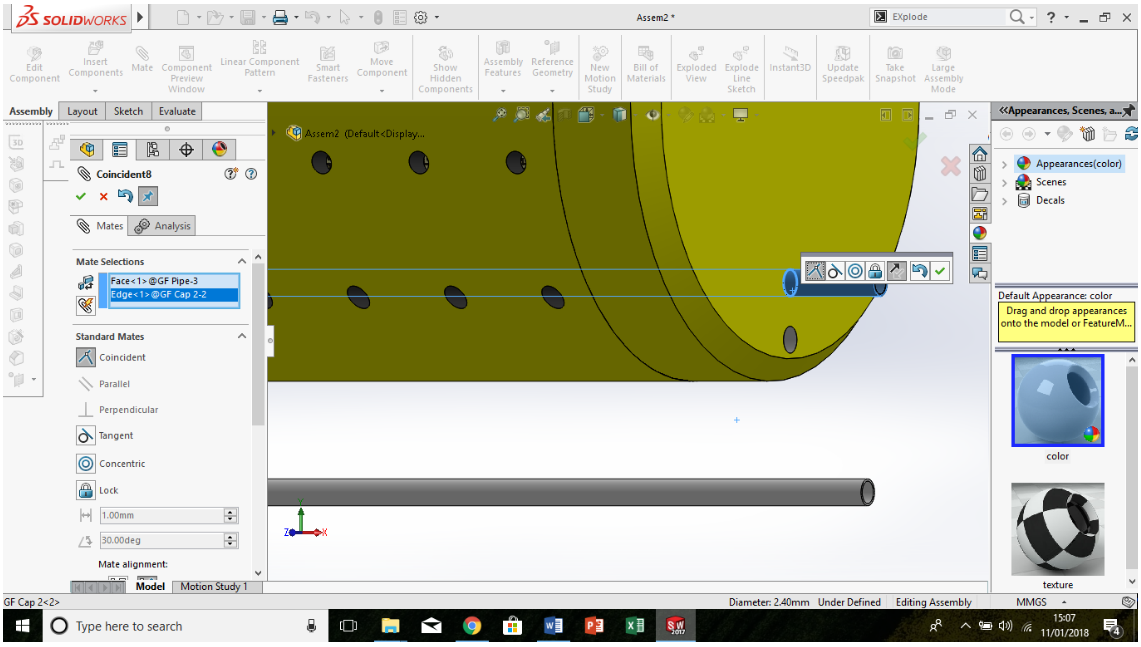

Figure 63 SolidWorks Waste Pipe Mate

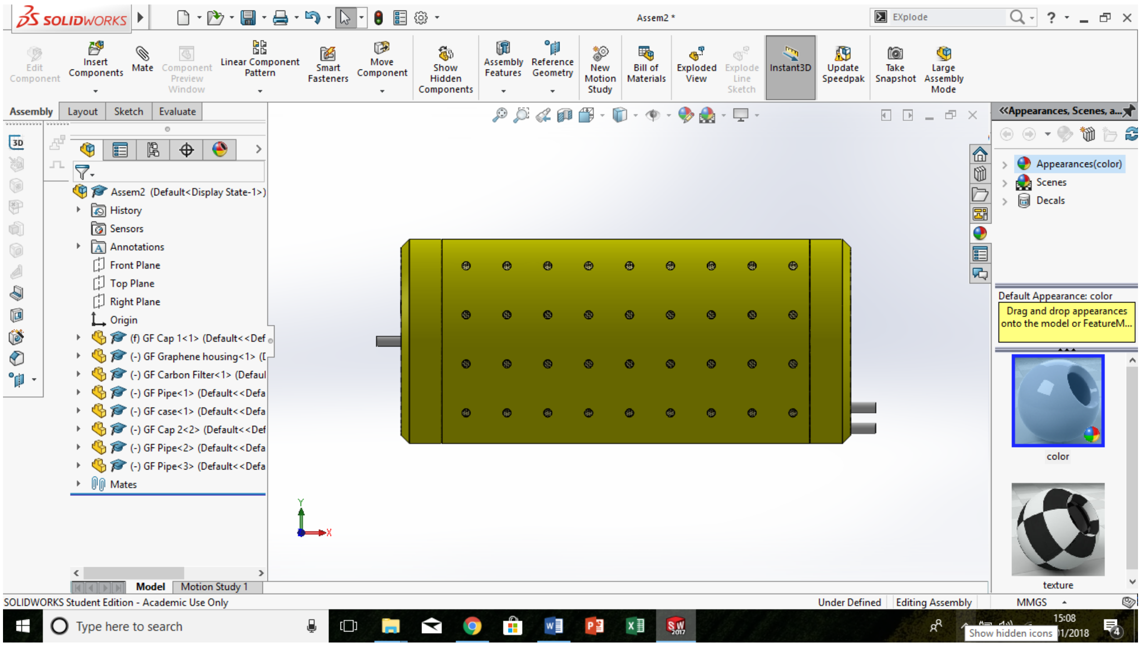

Figure 64 SolidWorks Waste Pipe Mate

Step 8

Finished Design.

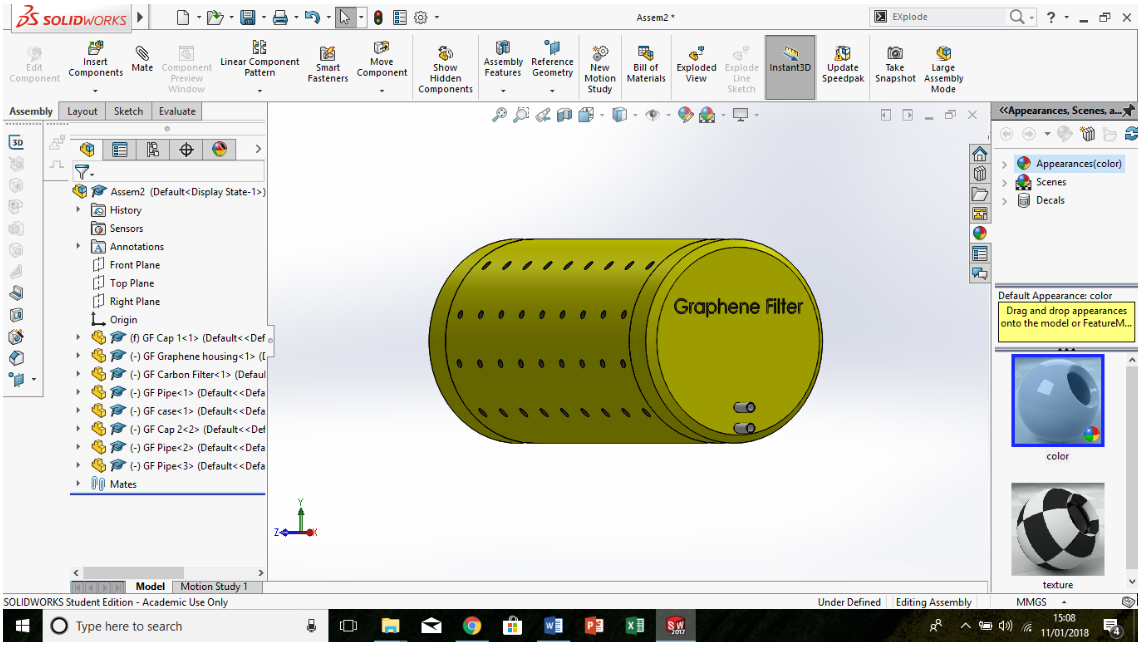

Figure 65 SolidWorks Finished Design

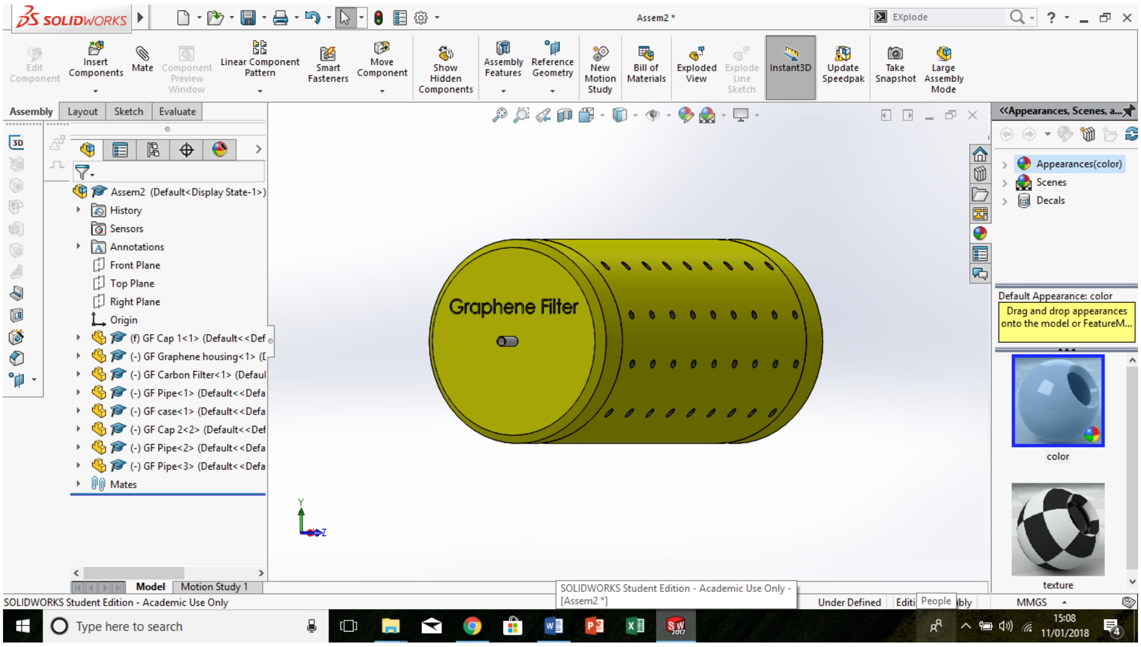

Figure 66 SolidWorks Finished Design

Product Viewing Gallery

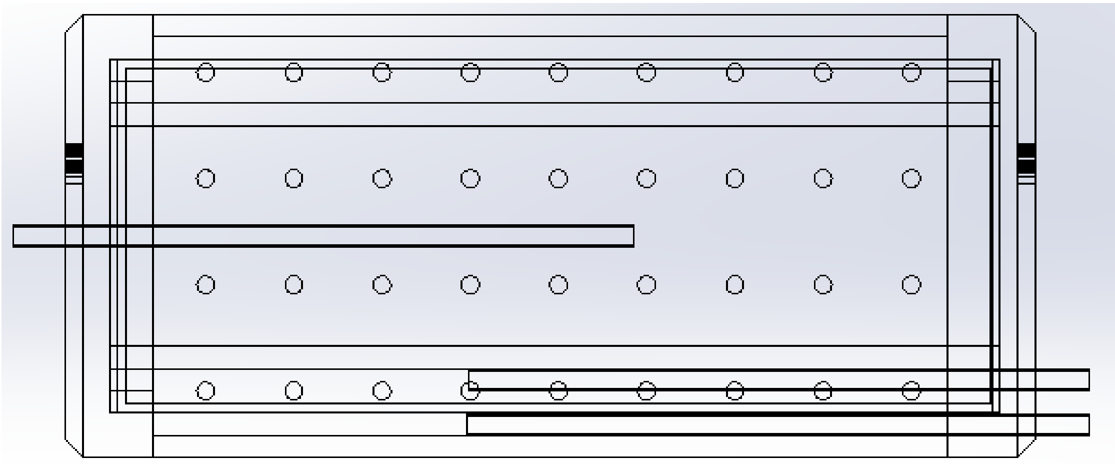

Figure 67 Wire Frame Product Viewing Gallery

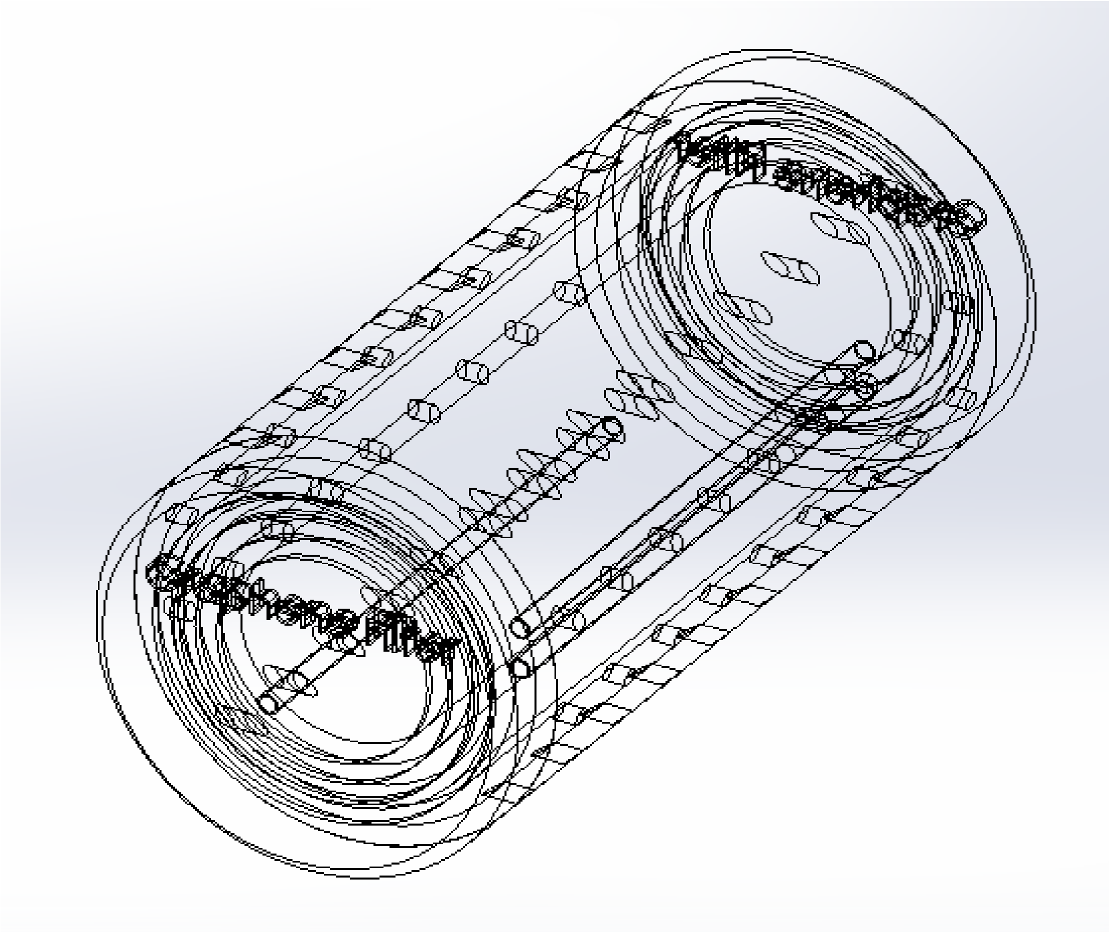

Figure 68 Angled Wire Frame Product Viewing Gallery

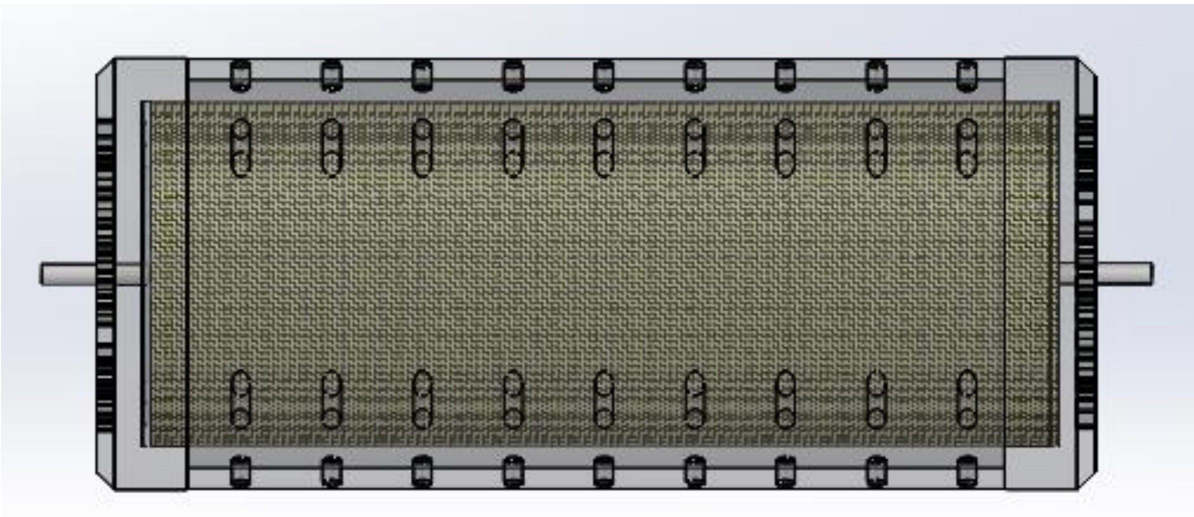

Figure 69 Transparent View

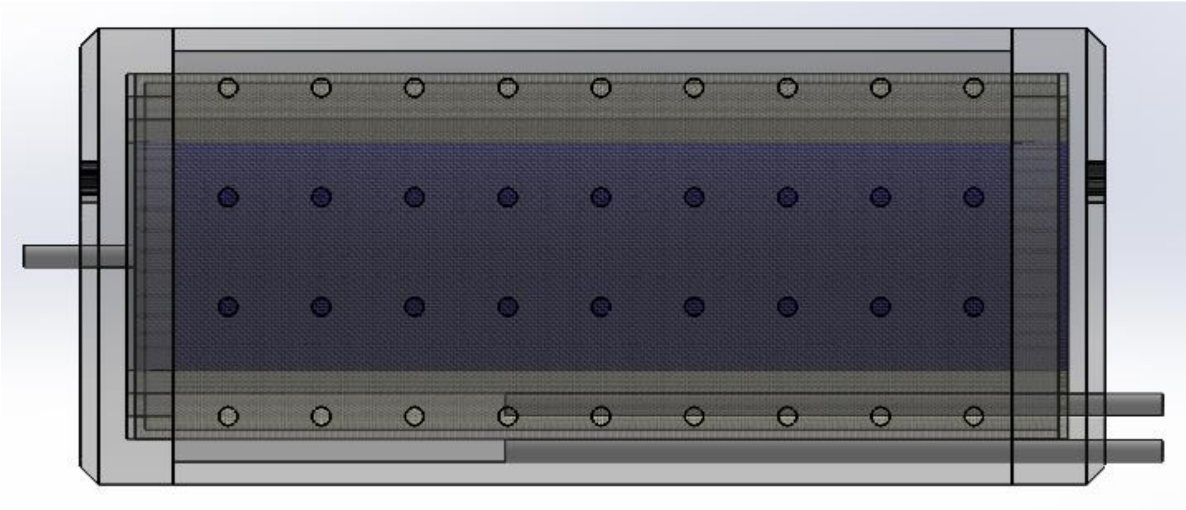

Figure 70 Transparent View

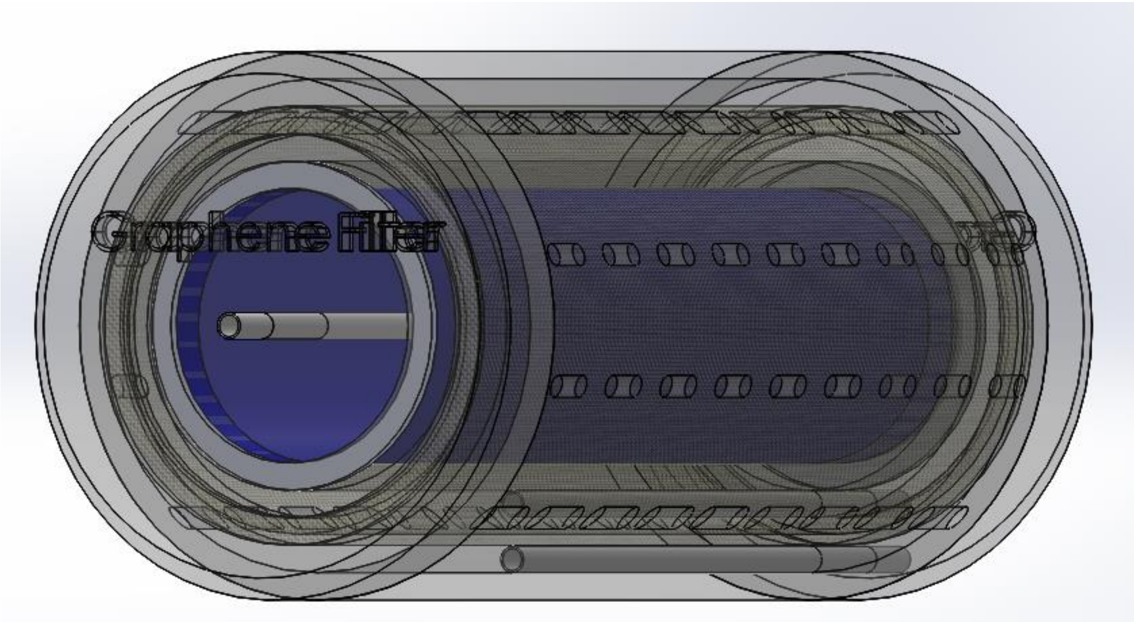

Figure 71 Transparent View

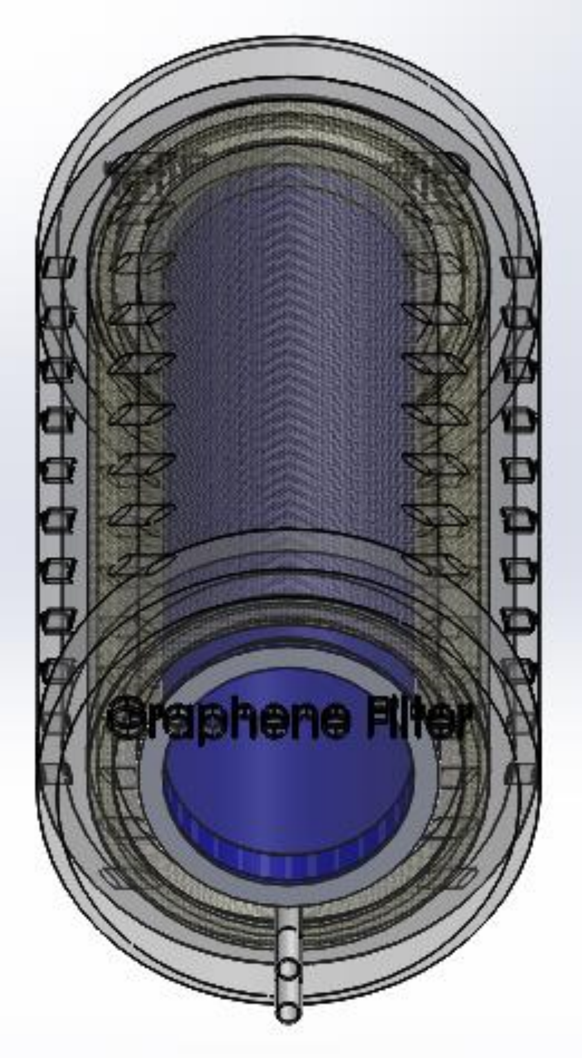

Figure 72 Transparent View

Finite Element Analysis

HDPE Properties

Property	Value	Units
Elastic Modulus	1070000000	N/m^2
Poisson's Ratio	0.4101	N/A
Shear Modulus	377200000	N/m^2
Mass Density	952	kg/m^3
Tensile Strength	22100000	N/m^2
Compressive Strength		N/m^2
Yield Strength		N/m^2
Thermal Expansion Coefficient		/K
Thermal Conductivity	0.461	W/(m·K)

Figure 73 HDPE Properties

Tensile strength is huge in terms of Newtons, and I have calculated a down force of 2 Newtons acting on the Prototype however, considering wave power we need to make the housing extra resilient, high tensile strength equals life cycles giving rise to warranty related issues, however the housing will outlive the carbon and graphene, so replacements of just these parts make the product cheaper and reusable.

Step 1

fix ends

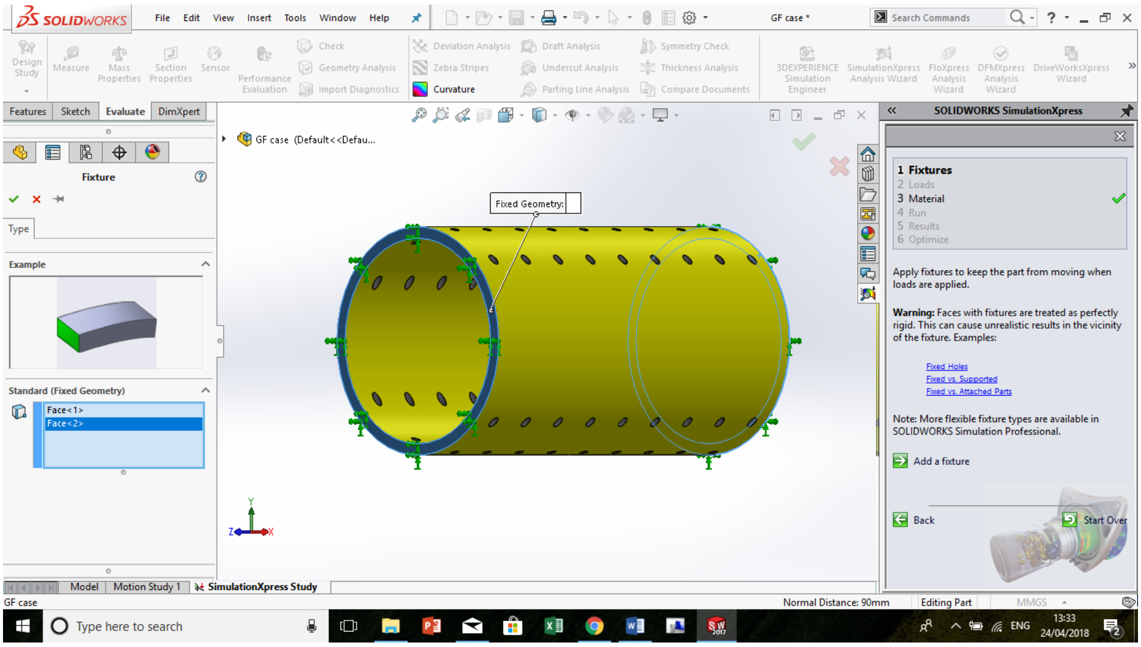

Figure 74 SolidWorks Fixed Ends

Step 2,

add forces of 2N

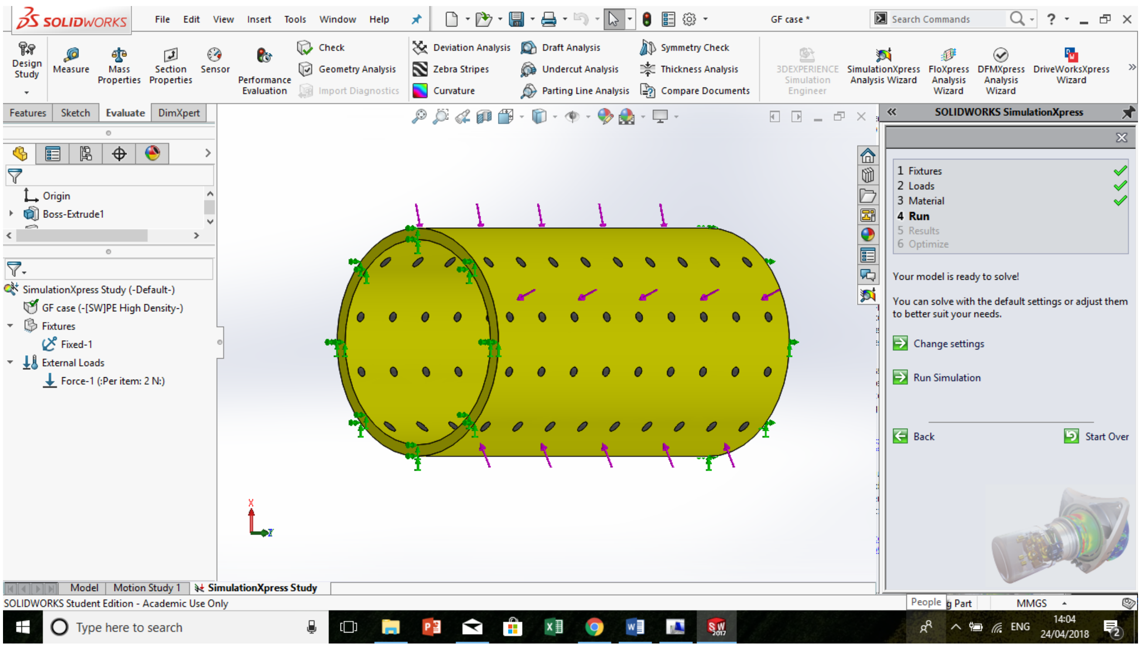

Figure 75 SolidWorks Force

Step 3

Run simulation these pictures show contraction and expansion.

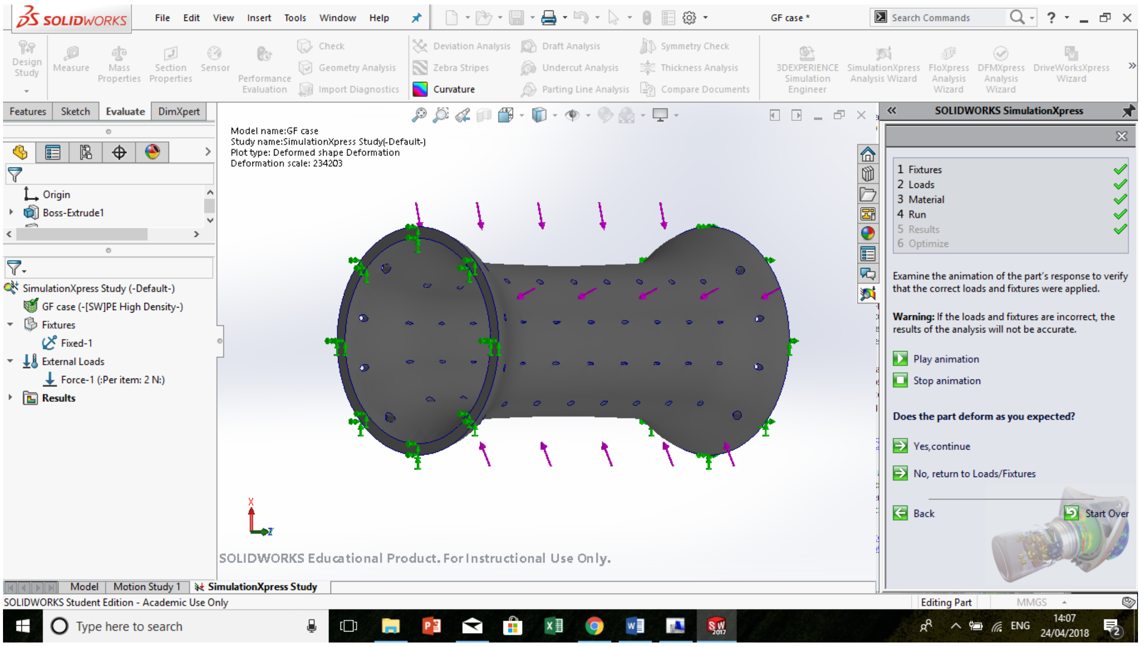

Figure 76 SolidWorks Simulation Run

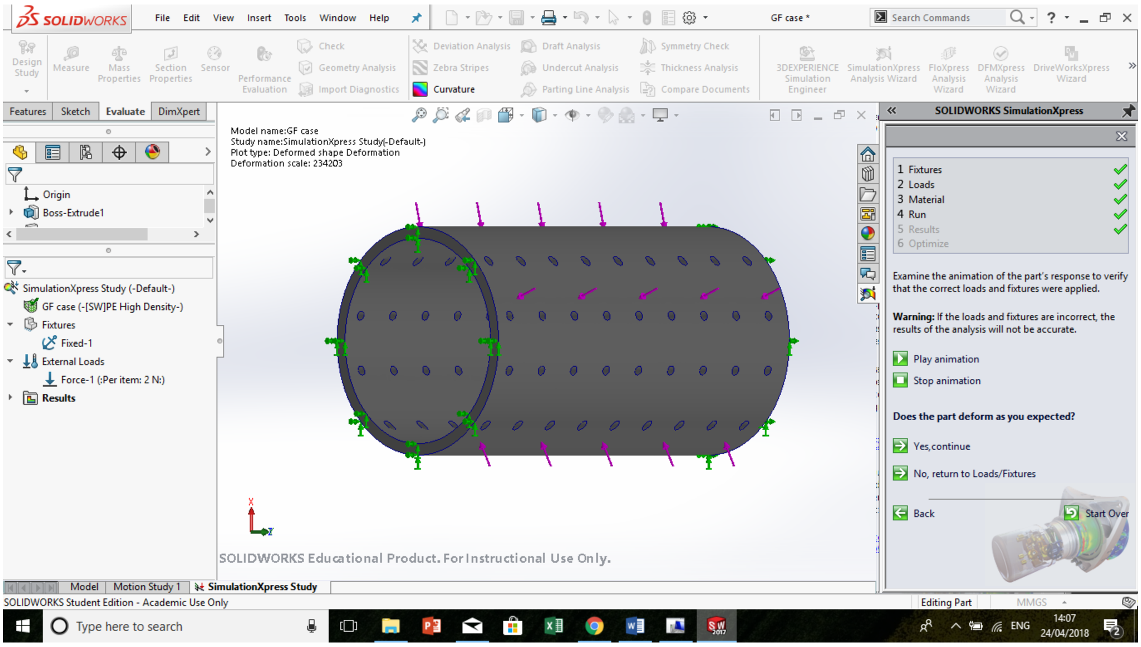

Figure 77 SolidWorks Simulation Run

Step 4

Von Mises, Shows the yield criteria, evidently the stress is Low.

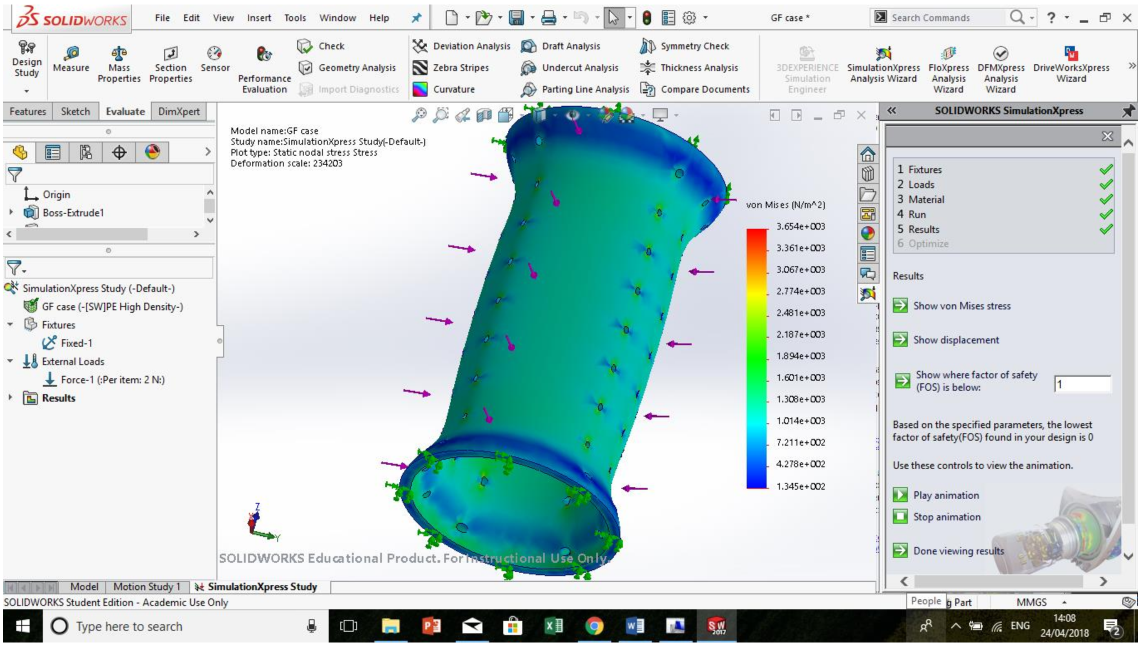

Figure 78 SolidWorks Von Mises

Step 5

shows the displacement and the corresponding heat factor.

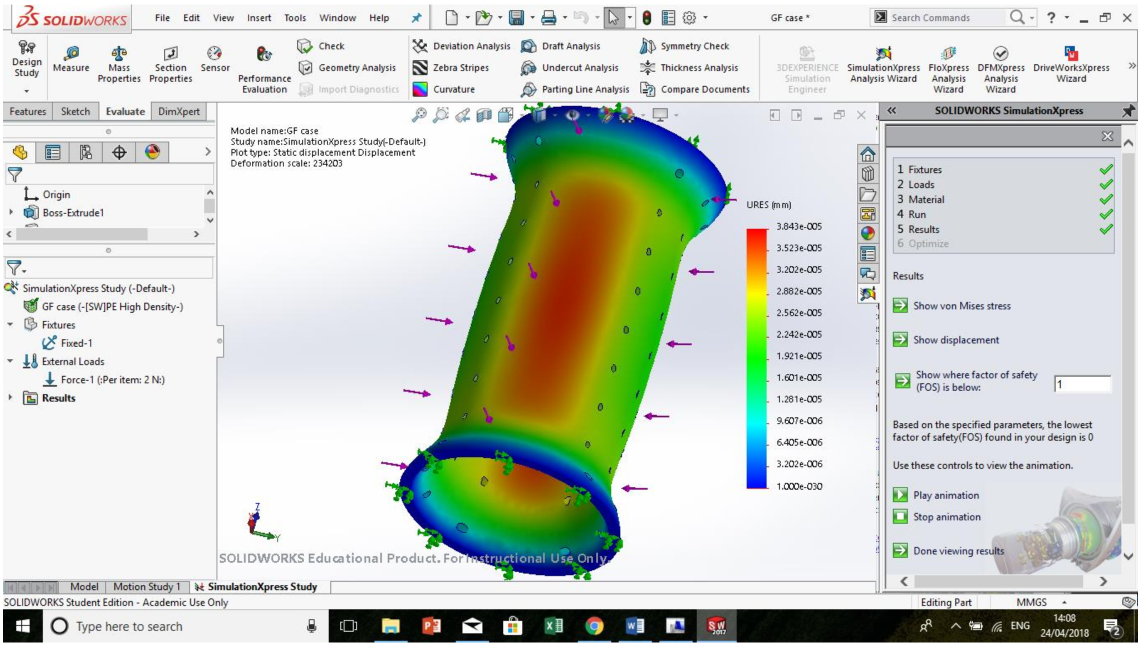

Figure 79 SolidWorks Displacement

2D Macroscopic Drawing

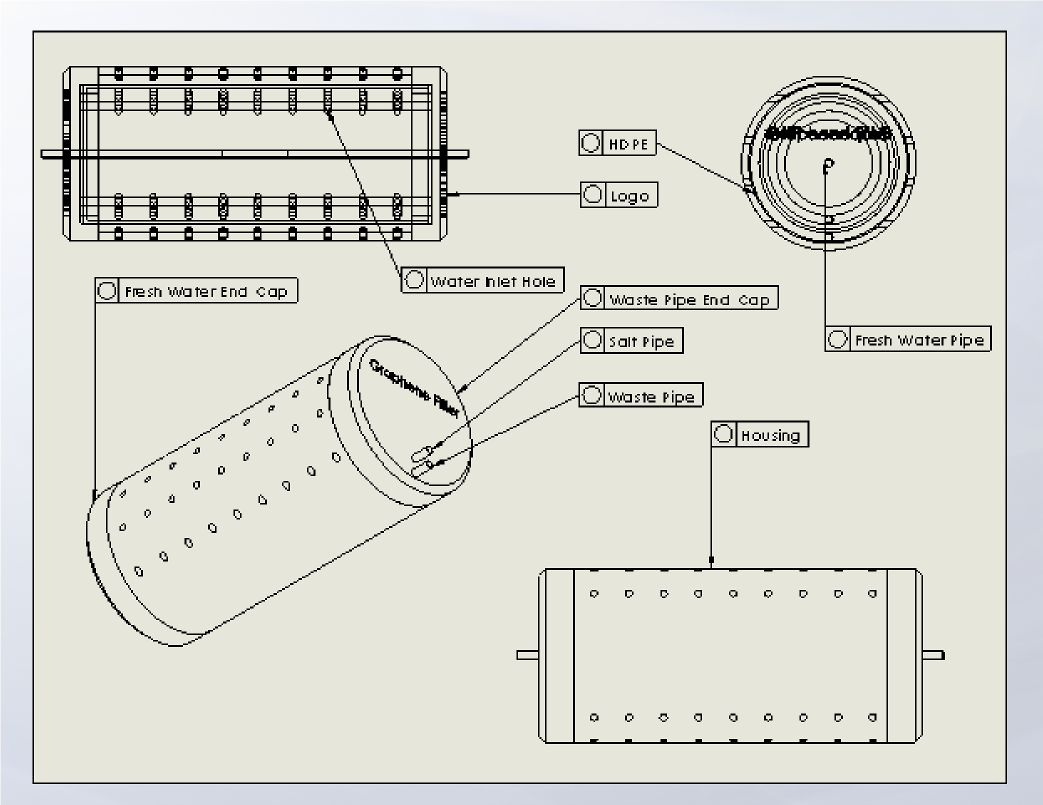

Figure 80 2D Macroscopic Drawing

Critical Analysis

Designing a sea worthy vessel that delivers fresh water would have to be of a robust design, demonstrated above via material selection and erection, methodologies concluded in the final design, the problem I have is that due to the fact nobody has ever tried to filter sea water in this way it may lead to problems I cannot for see, rather than trying to calculate pumps and a suitable flow rate method, I would like to test the system using voltage regulated pumps to find the ideal balance, graphene oxide membrane according to research suggests that if it was used as a filter the filter would act as if it was not there at all, the product designed is a prototype and I personally think a hands on approach is required in order to see where the design could be improved.

Graphene is 200 times stronger than steel therefore I am neglecting testing as its strength its already proven, testing the housing through FEA has been used to select the appropriate materials, the Carbon was upgraded from foam to pellets as the gaps between them are much smaller which catches more toxins, pumps reduce debris and build-up of unwanted materials that may reduce life expectancy by blocking the filters at all levels, elongated design allows for a greater area and less build-up of debris. Trying to force sea water through a concentrated area is not the method I would use as blockages would be frequent increasing maintenance.

The cost of the graphene is ultimately the main problem, when production picks up then it will become cheaper to manufacture, I hope to contribute towards the production of graphene, and get that ball rolling faster than it ever would without a graphene filter, I also aim to provide people jobs all over the world.

Life expectancy of the graphene filter is undetermined, and tests would need to be carried to improve its life cycle if it needed it, it may not, the fact is I don't know, how it will perform, but the one thing I am confident about is that it will work. I would physically like to see it to improve it, theoretical calculations may not be the method that would work alone, a combination will be utilised with expert advice from mathematicians, environmentalists, engineer teams and plenty of research and development.

Flowrate Analysis

Due to my project only being of BSc level flow analysis software has not been granted to me, so I may be lacking a few calculations in that respect and to be honest it's the most important part of this project, I have been informed it's of master's level.

Pulsing Pumping System

I will be saving this section as part of my Masters if I get the chance, but to briefly mention that the pumps will work reversibly utilising a pulsing methodology, this agitates debris build up, pushing fluid back and forth, pumps will be programmed into a sequence which will only be done once the prototype is built, automatic phase swapping on the pumps will allow for this action to happen, the pumps will have different flow rates at different times this process will improve life expectancy and make sure the filter works correctly.

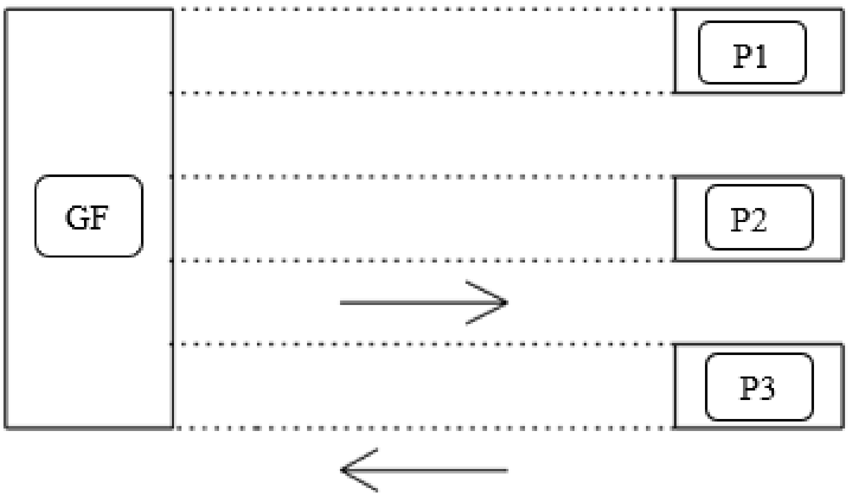

Figure 81 Pulsing Pumps

Intellectual Property

Patented Documents

BUSINESS INNOVATION AWARDS
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UK's Leading Invention Development Company

Mr Chris Rooney
30 West Street
Syston
Leicestershire
LE7 1HT

11 January 2018

Dear Mr Rooney,

Thank you for your recent enquiry.

At Innovate Design, we support and encourage individuals who are looking to profit from their new product ideas.

Before spending any money on the project, we would be happy to review the idea, in confidence, and at no cost, to establish whether we can help you. We will look at how best to protect and develop your idea. It will also help determine future costs, if any, and potential funding opportunities to start production.

We have enclosed an **Idea Submission form on the reverse side** of the non-disclosure agreement and a freepost envelope, should you wish us to complete this review. For your protection, we have also enclosed a signed confidentiality agreement. This is a legally binding document that prohibits us from revealing your idea to anyone, or commercialising it in any way, without your permission.

We can assure you of the following points:

- All information will be handled in the strictest confidence.
- We do not charge any fees to review the idea.
- You will retain 100% ownership of the idea and therefore 100% of any future profit.
- We have a proven track record of helping individuals patent, develop and sell their ideas.

For your peace of mind, we were first accredited by Business Link, part of the DTI, in 2002.

The first step would be to sign the enclosed confidentiality agreement, fill in the Idea Submission form on the reverse and return them to us in the freepost envelope provided.

We look forward to reviewing your idea, however if we cannot help you, we will try to point you in the right direction of other organisations that could. If you have any questions feel free to call us on: 020 7354 5640.

Yours sincerely,

Alastair Swanwick
Managing Director

The material in this letter is commercially focussed and generalised information and opinion about successfully working within the existing legal framework of intellectual property, patents and patent law, and should in no way be viewed or construed as legal advice. Advisors at Innovate are not and will not be lawyers unless this is specifically stated, so we advise you to contact a specialised intellectual property lawyer if you feel you need specific legal information and tactical advice.

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Europe Mainland: Tour Montparnasse, 26ème étage, 33 avenue du Maine, 75015 Paris
USA Office: 369 Pine Street, Suite 103, San Francisco CA 94104 USA
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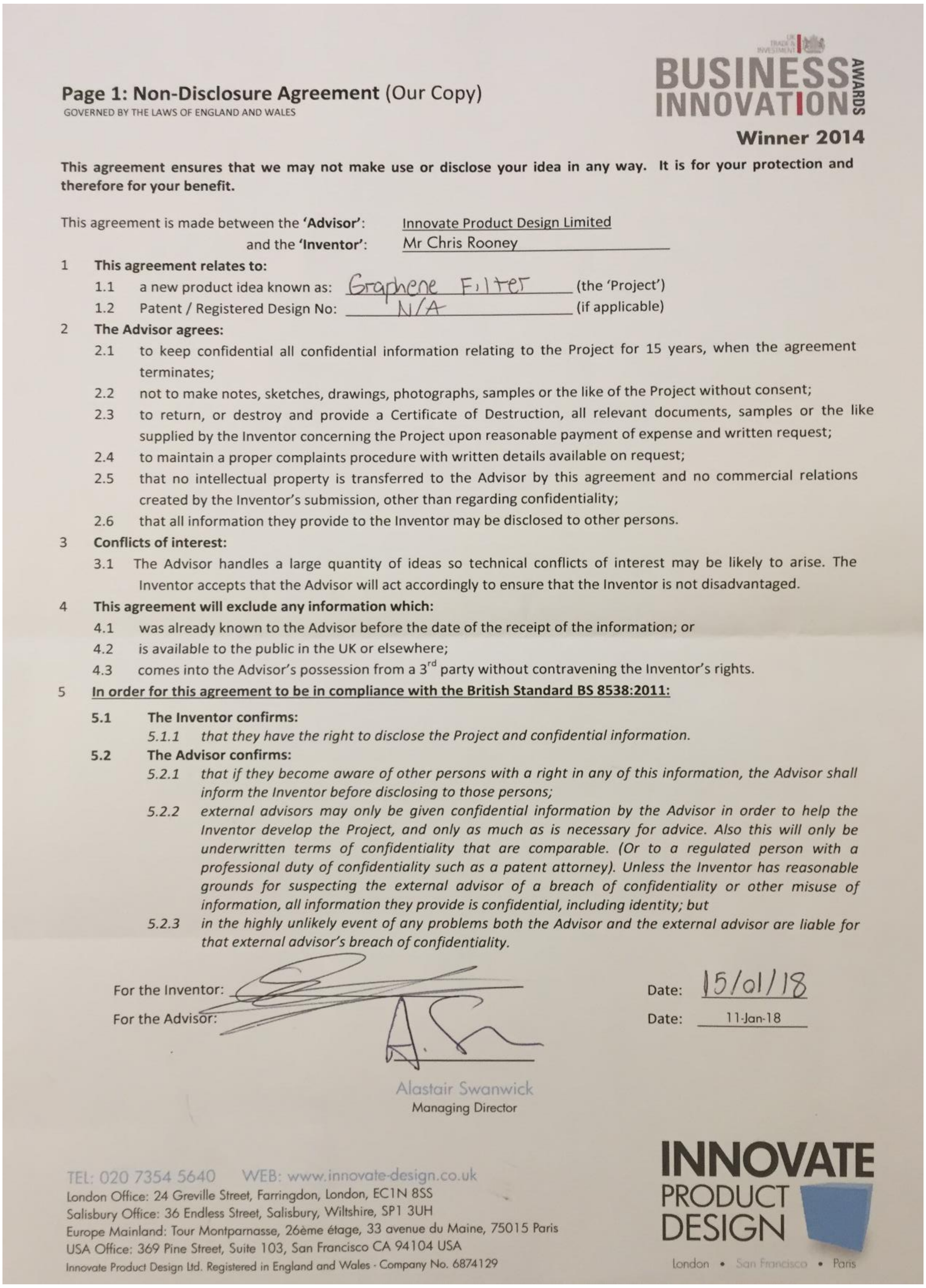
Figure 82 Intellectual Property



Page 1: Non-Disclosure Agreement (Our Copy)
GOVERNED BY THE LAWS OF ENGLAND AND WALES

BUSINESS INNOVATION AWARDS
Winner 2014

This agreement ensures that we may not make use or disclose your idea in any way. It is for your protection and therefore for your benefit.

This agreement is made between the **'Advisor'**: Innovate Product Design Limited
and the **'Inventor'**: Mr Chris Rooney

1 **This agreement relates to:**
- 1.1 a new product idea known as: Graphene Filter (the 'Project')
- 1.2 Patent / Registered Design No: N/A (if applicable)

2 **The Advisor agrees:**
- 2.1 to keep confidential all confidential information relating to the Project for 15 years, when the agreement terminates;
- 2.2 not to make notes, sketches, drawings, photographs, samples or the like of the Project without consent;
- 2.3 to return, or destroy and provide a Certificate of Destruction, all relevant documents, samples or the like supplied by the Inventor concerning the Project upon reasonable payment of expense and written request;
- 2.4 to maintain a proper complaints procedure with written details available on request;
- 2.5 that no intellectual property is transferred to the Advisor by this agreement and no commercial relations created by the Inventor's submission, other than regarding confidentiality;
- 2.6 that all information they provide to the Inventor may be disclosed to other persons.

3 **Conflicts of interest:**
- 3.1 The Advisor handles a large quantity of ideas so technical conflicts of interest may be likely to arise. The Inventor accepts that the Advisor will act accordingly to ensure that the Inventor is not disadvantaged.

4 **This agreement will exclude any information which:**
- 4.1 was already known to the Advisor before the date of the receipt of the information; or
- 4.2 is available to the public in the UK or elsewhere;
- 4.3 comes into the Advisor's possession from a 3rd party without contravening the Inventor's rights.

5 **In order for this agreement to be in compliance with the British Standard BS 8538:2011:**

5.1 The Inventor confirms:
- *5.1.1 that they have the right to disclose the Project and confidential information.*

5.2 The Advisor confirms:
- *5.2.1 that if they become aware of other persons with a right in any of this information, the Advisor shall inform the Inventor before disclosing to those persons;*
- *5.2.2 external advisors may only be given confidential information by the Advisor in order to help the Inventor develop the Project, and only as much as is necessary for advice. Also this will only be underwritten terms of confidentiality that are comparable. (Or to a regulated person with a professional duty of confidentiality such as a patent attorney). Unless the Inventor has reasonable grounds for suspecting the external advisor of a breach of confidentiality or other misuse of information, all information they provide is confidential, including identity; but*
- *5.2.3 in the highly unlikely event of any problems both the Advisor and the external advisor are liable for that external advisor's breach of confidentiality.*

For the Inventor: Date: 15/01/18
For the Advisor: Date: 11-Jan-18

Alastair Swanwick
Managing Director

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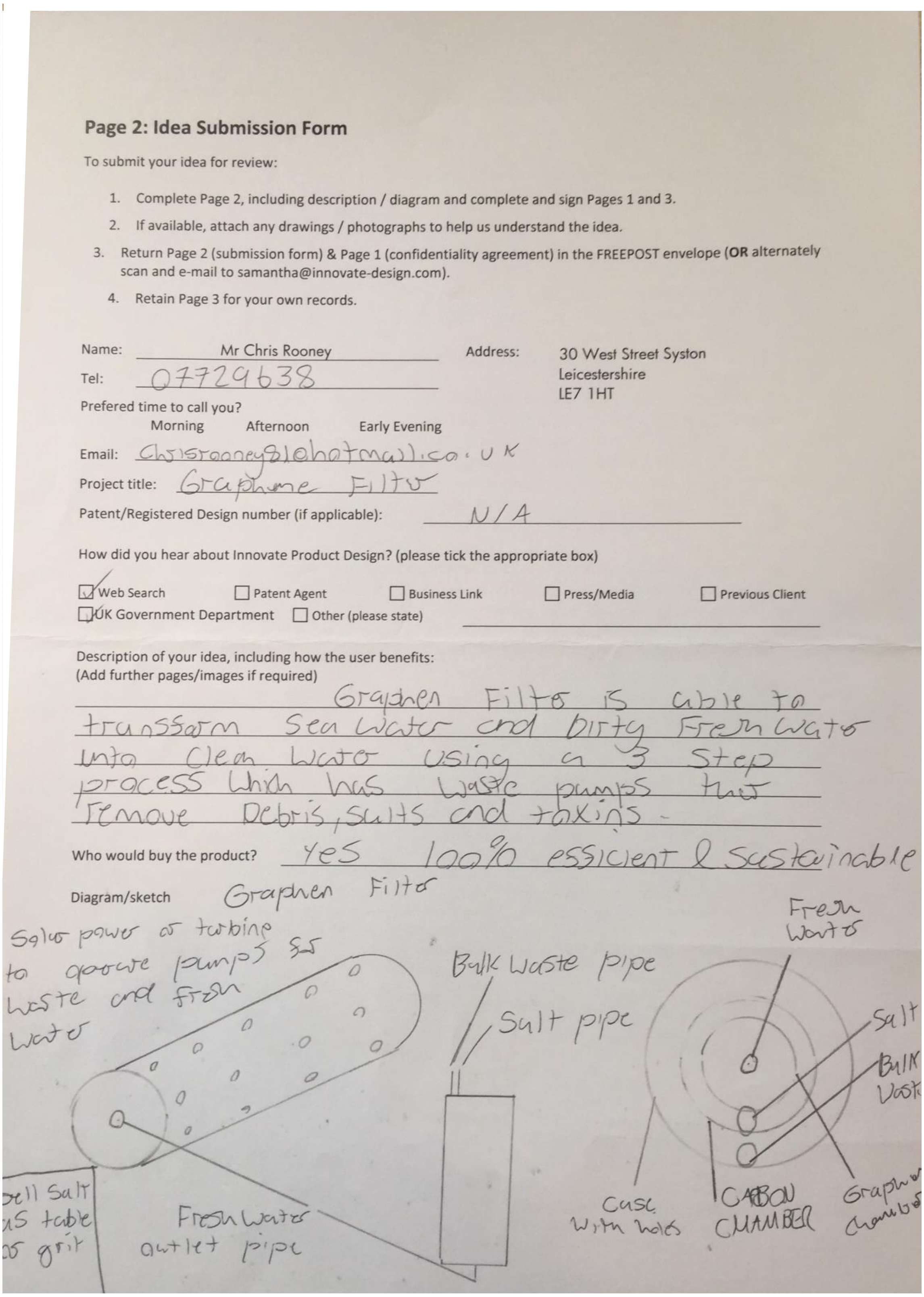
Figure 83 Intellectual Property



Page 2: Idea Submission Form

To submit your idea for review:

1. Complete Page 2, including description / diagram and complete and sign Pages 1 and 3.
2. If available, attach any drawings / photographs to help us understand the idea.
3. Return Page 2 (submission form) & Page 1 (confidentiality agreement) in the FREEPOST envelope (**OR** alternately scan and e-mail to samantha@innovate-design.com).
4. Retain Page 3 for your own records.

Name: Mr Chris Rooney
Address: 30 West Street Syston Leicestershire LE7 1HT
Tel: 07729638

Prefered time to call you?
Morning Afternoon Early Evening

Email: Chrisrooney81@hotmail.co.uk
Project title: Graphene Filter
Patent/Registered Design number (if applicable): N/A

How did you hear about Innovate Product Design? (please tick the appropriate box)

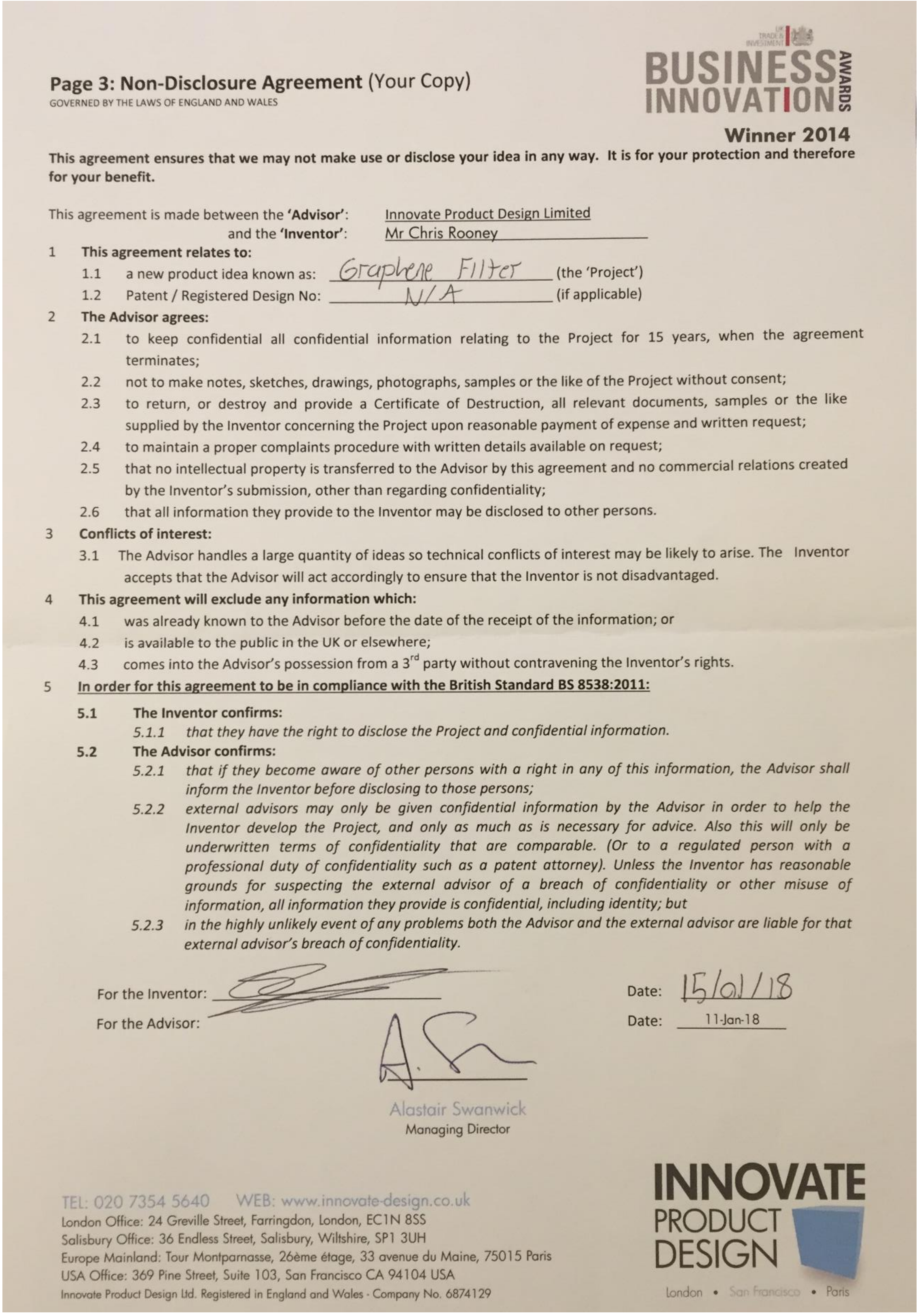
☑ Web Search ☐ Patent Agent ☐ Business Link ☐ Press/Media ☐ Previous Client
☐ UK Government Department ☐ Other (please state)

Description of your idea, including how the user benefits:
(Add further pages/images if required)
Graphen Filter is able to transform Sea Water and Dirty Fresh Water into Clean Water using a 3 step process which has waste pumps that remove Debris, Salts and toxins.

Who would buy the product? Yes 100% efficient & sustainable

Diagram/sketch Graphen Filter

Figure 84 Intellectual Property



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For the Inventor: ________ Date: 15/01/18

For the Advisor: ________ Date: 11-Jan-18

Alastair Swanwick
Managing Director

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Figure 85 Intellectual Property

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Appendix

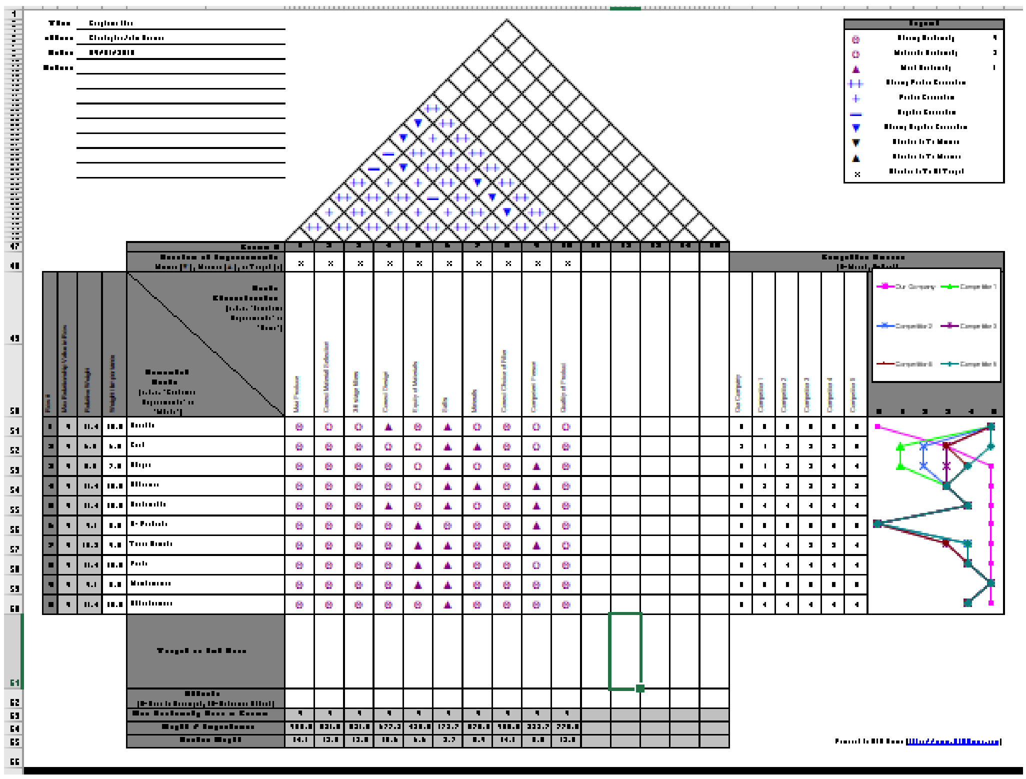

Figure 86 House of Quality