



Engineering Problem
Engineering Design Materials ACHA4001

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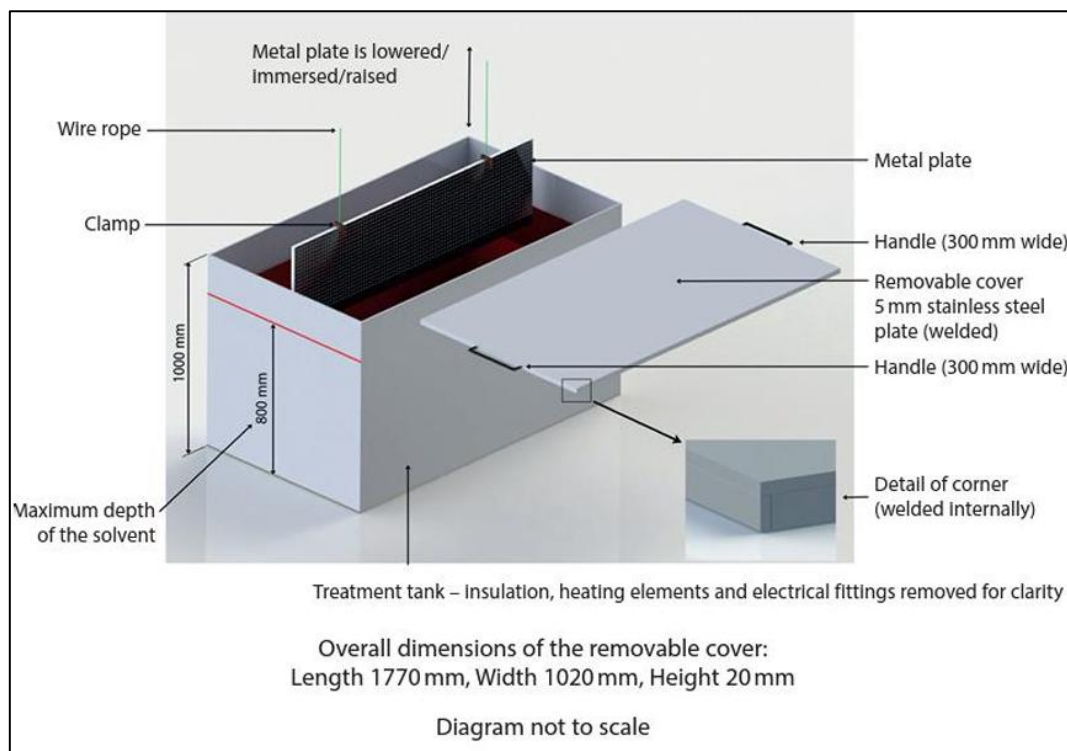
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1 Introduction

This project requires a treatment tank as seen in Figure 1-1 to be re-designed to help make the process of covering the tank with its current lid much easier. However, this is not the only requirement the treatment tank contains 30% sulphuric acid and is heated to 25°C and with the staff complaining that it is particularly challenging to attach the lid correctly a large health and safety risk emerges. This operation has been verified as a risk by a health and safety officer. The new design will be made to be operated by one person rather than two and will guarantee the safety of the staff while in operation.



2 Legislation and Design Specifications

2.1 Key Legislation Considerations

Key legislation that has to be considered are:

- Health and Safety at work act (HSWA) 1974
- Chemical Regulations (CHIP) 2002
- Manual Handling Operations Regulations (MHOR) 1992
- Lifting Operations and Lifting Equipment Regulations (LOLER) 1998
- Provision and Use of Work Equipment Regulations (PUWER) 1998

It must also be noted that women are not advised to lift more than 16kg and men no more than 25kg while at work. This is in accordance with the guidelines provided via the health and safety executive at the time of the HSWA 1974 (MITAL 1984).

2.2 Specifications

With clearance being needed above the tank it eliminates any idea of lifting the lid vertically, having two handles is now no longer needed as the lid must be operated by one person. The tank lid being quite heavy may have to be amended if one person is now in control for even if the weight is halved a single person would still be carrying their share of the weight they were originally carrying. The current weight of the lid is approximately 72.36kg which is quite heavy for one person to lift.

The time needed to complete this project is around 6-8 weeks for this business cannot put its staff at risk of using the unsafe and heavy lid for much longer at all. This product will be specifically designed for this business for it would be rare to find another client with this same issue however this business needs the product for all of its other sites and facilities. My product must meet these requirements:

- Must be safe to use.
- Must be able to be operated by one person.
- Must be clearance from above to allow parts to be lowered into the tank.
- Tank dimensions and materials remaining the same (Modifications allowed)
- Tank lid can be altered as the designer sees fit.

My product will remain the current size of the original tank lid which the dimensions are 1770mm length, 1020mm width and 20mm height to ensure a perfect fit onto the tank. Aesthetically there is no real concern on making my product stand out in any way other than ensuring it fits in with the current tank whether that means matching the colour or style.

3 Time plan

The time plan for the project is as set out below in Figure 3-1

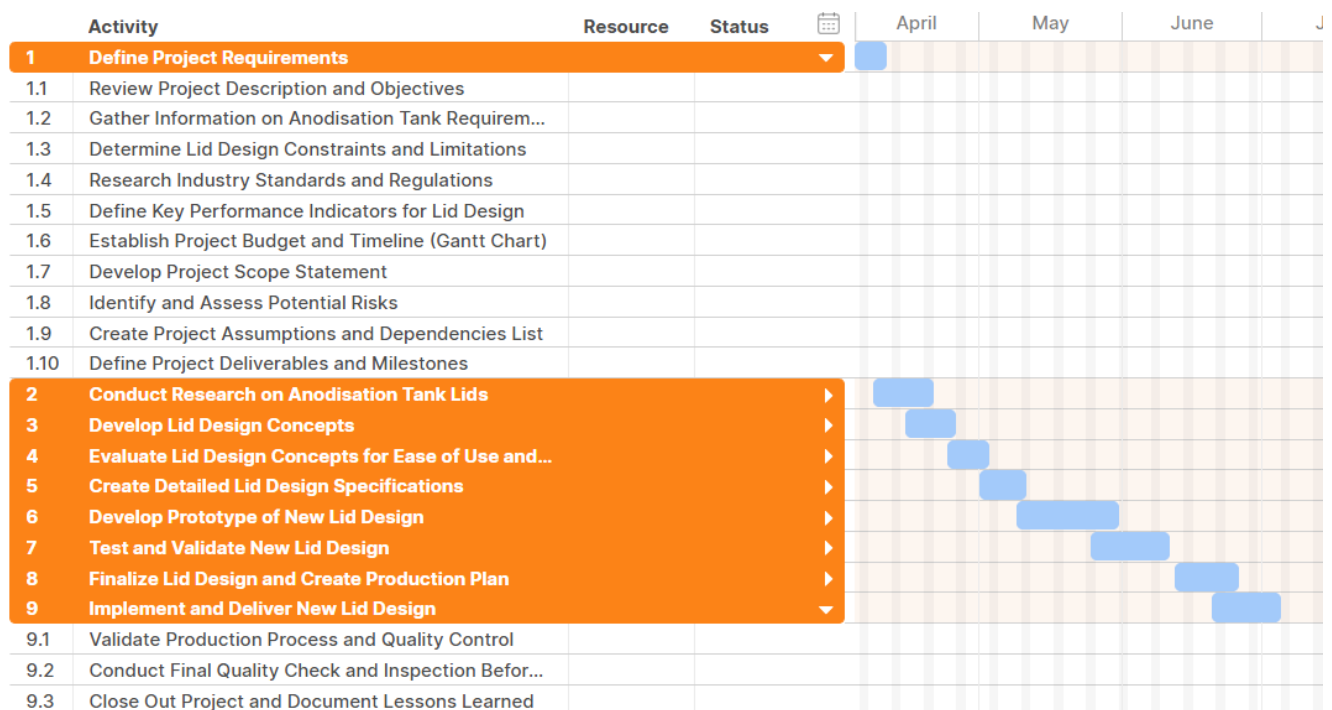


Figure 3-1: Gantt chart displaying the time plan (Tomsplanner)

The Gantt chart displays nine sections overall with section one and nine showing each individual task within the overall topic.

4 Research

4.1 Materials

There are many varied materials that can be considered for the tank lid with many different properties. The material must be corrosion resistant, resistant to sulphuric acid and be able to work in temperature conditions of 25°C but some of the best all round materials consist of different grades of stainless-steel, high-density polyethylene and nickel alloys. Although for stainless steel the different grades effect many distinct aspects of the material itself for example Alloy 20 is overall the best for its corrosion resistance, good weldability and being specifically designed for sulphuric acid resistance but costs around £7 per kg (Corrotherm 2018). However, alloy 904L is remarkably similar with a higher acidic resistance and cheaper being £5.50 per kg. The most cost-effective choice is 317L being £3.50 per kg and it is not as resistant to acid or corrosion but is still resistant enough to be considered. With options such as high-density polyethylene the price is not an issue being £0.85 per kg but the actual strength and durability of the material comes into question as it would need to be reinforced or made thicker than the steel for it is not naturally as durable as stainless steel (Granta, 2025).

4.2 Environmental

Ensuring sustainability is a top priority is crucial today hence why choosing a manufacturer and supplier that adheres to being sustainable is of the utmost importance. Manufacturing adds up to a fifth of world greenhouse gas (GHG) emissions and takes up almost half of the world's energy usage (Grozier 2024). It must be recognised that most plastics are derived from fossil fuels and contribute to GHG emissions whereas metals can mostly be recycled after the end of the products lifecycle. Waste reduction is important and considering what manufacturing method will be used will directly affect this, for example machining metals will produce lots of waste in forms such as swarf while casting or moulding has much less waste (Bunty 2022). Materials like (HDPE) can bought recycled and then recycled after its use as well which would be bulk bought for £225-£365 per tonne depending on the grade of recycled HDPE bought (Green, 2015).

4.3 Economic Considerations

Furthermore, high skilled manufacturing processes will come at a much higher cost than a generic process. For example, casting for an intricate design would be challenging hence being costly. It is similar for machining with CNC being less cost effective the less a component is produced, this means doing a bulk order for every tank lid would save lots of money (Smoothy 2024).

The cost of the materials that would be used have to be carefully considered for the tank lid must be produced for every tank at every facility for the client. Comparing a generic stainless steel and HDPE for example the steel would cost between £2.12-£2.27 per kg, and HDPE would cost between £0.85-£0.86 per kg. However, the different grades of steel would differ in cost, alloy 904L costs approximately £5 per kg and AISI 317L costs around £3.50 per kg.

4.4 Production

The production of the product is particularly important with having to consider different manufacturing methods and what they can achieve for the product and whether those benefits what the client needs. Firstly, CNC machines could be a great choice for working with a range of different materials especially the three identified in section 4.1. However, metals are much easier to machine compared to plastics even though plastics are more cost effective (Hepburn 2024). To create high-quality stainless-steel parts casting, machining and welding are to be considered. For stainless steel 317L all common fusion and resistance methods except oxyacetylene welding have proven successful (Penn 2025). Hot rolling is another technique to create sheets of 317L from as thin as 0.4mm up to 50mm thick (Steelpro 2025).

The use of standardisation will be crucial to reducing the overall cost of the final product. Standardisation can result in a 50% reduction in manufacturing costs while producing a high-quality, low-cost product. This can be as simple as using less materials, less tools and less components. By using less materials for example only using one or two materials instead of 5+ money and waste can be saved by bulk ordering more of a single material rather than lesser amounts of multiple materials. Making the product need the use of less tools simplifies the installation and any repairs/maintenance that the product will need to receive

throughout its lifecycle, shortening the time and tools needed for someone to be able to fix the product.

4.5 Lifecycle Considerations

Depending on the material used the lifespan of the product will differ. For example, if stainless steel or HDPE is used the lifespan of the product is expected to be between 10 & 20 years but if nickel alloy is used the life span is between 25-35 years which is significantly more (NeoNickel 2025). Nickel alloy is also quite easy to recycle and downcycle compared to stainless steel and HDPE which both can be recycled although it is more challenging to recycle. Stainless steel will most likely end up in landfill and HDPE can even be used to combust for energy recovery before going into landfill (Granta, 2025).

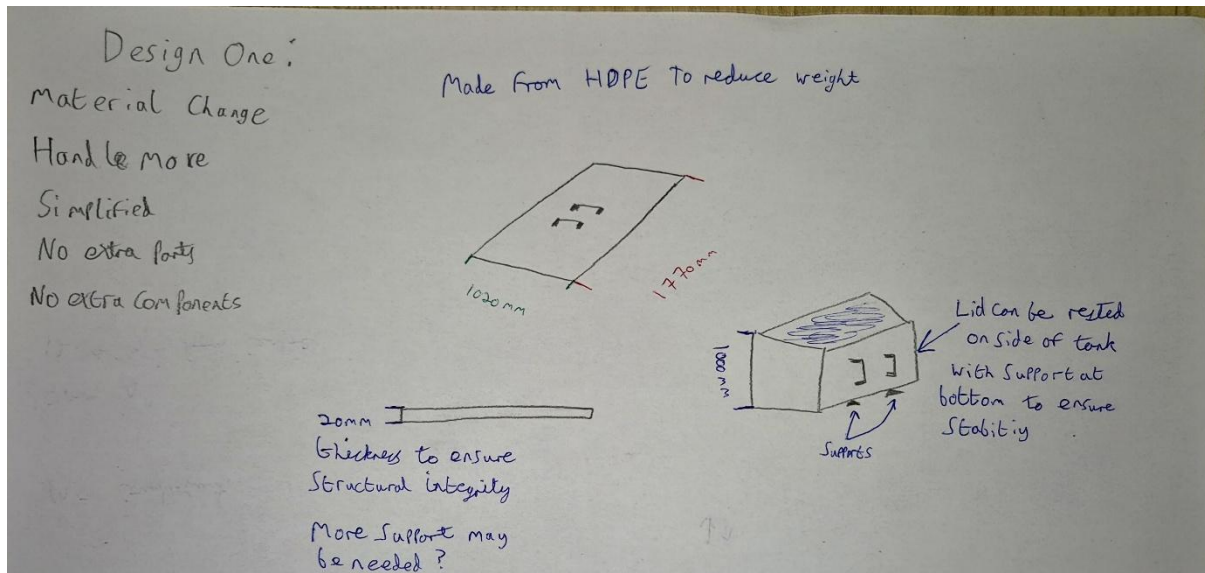
The design being modular could be quite important in the maintenance of the product as having any component that need changing be made as easy as possible would help in the upkeep of the product.

Maintenance on the product itself will be differ depending on the choice of design but for example any hinges that would be used on the product would need lubricating approximately every six months and sooner if any squeaking or stiffness is noticed (Ibarra 2024). Stainless steel should be seen to every 6-12 months and cleaned which will prevent corrosion (Hilscher 2019). However, nickel alloys need little maintenance due to their ability to hold their structural integrity over long periods of time (Intamet 2024). HDPE is similar with its low upkeep; it doesn't require much maintenance at all but should always be regularly inspected in case of component failure (Polyexcel, 2019).

5 Initial Sketches

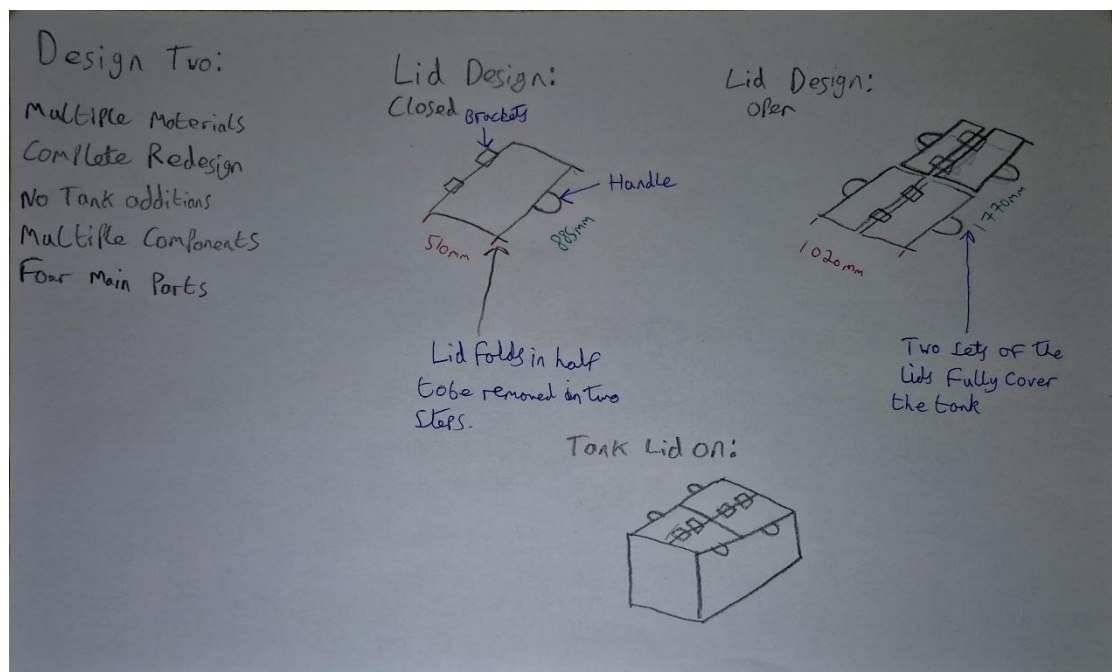
5.1 Design One

The first design idea was to just change the material to something lighter such as HDPE and move the handle of the box to make a single person capable of attaching and removing the lid which would look as seen below in Figure 5-1.



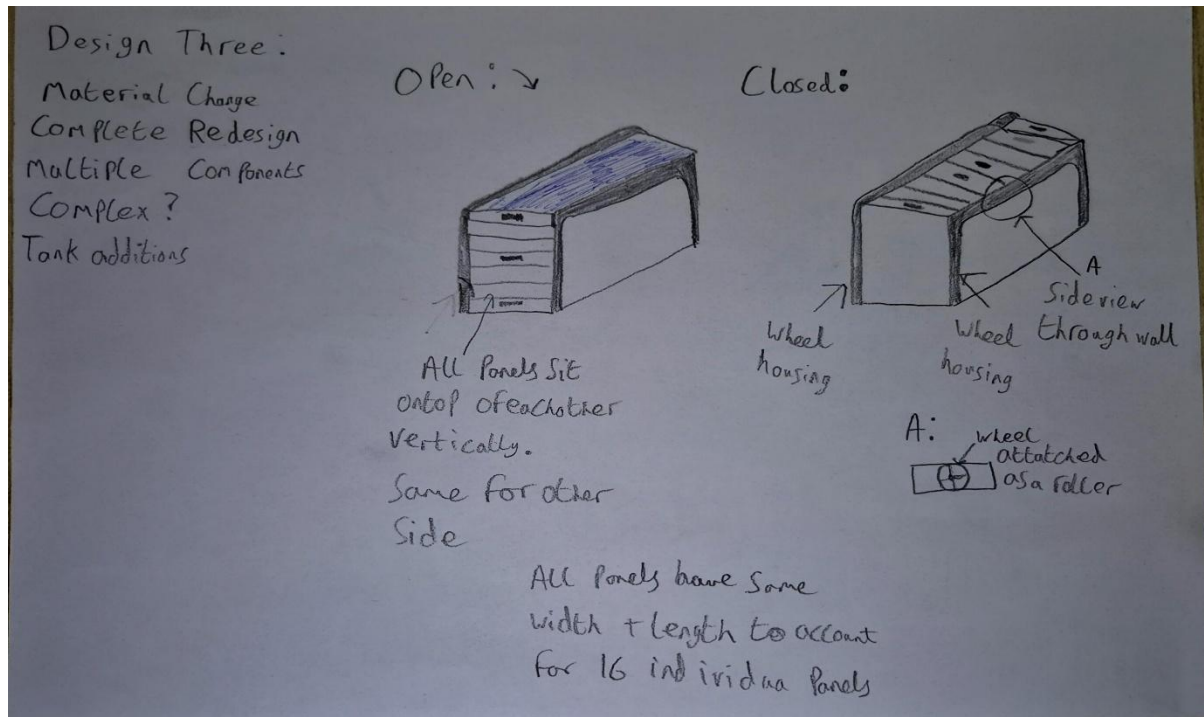
5.2 Design Two

Design two will split the tank into four individual quarters out together by hinges to result in two halves that fold over each other that can be taken off in a total four steps.



5.3 Design Three

For design three the tank lid gets split into 16 parts of equal length and width as seen in Figure 5-3 below



6 Final Design

6.1 Justification

For my final design I have chosen to produce design two, this is due to its ease of use as well as simple maintenance. Using a standardised hinges will make maintenance and replacement of the hinges cheap and remarkably simple. It also reduces the overall weight of the product which will ensure compliance with MHOR. Having no modifications made to the tank itself keeps the design simple as well as having no extra components other than the hinges and tank lid itself.

6.2 Computer Aid Design (CAD)

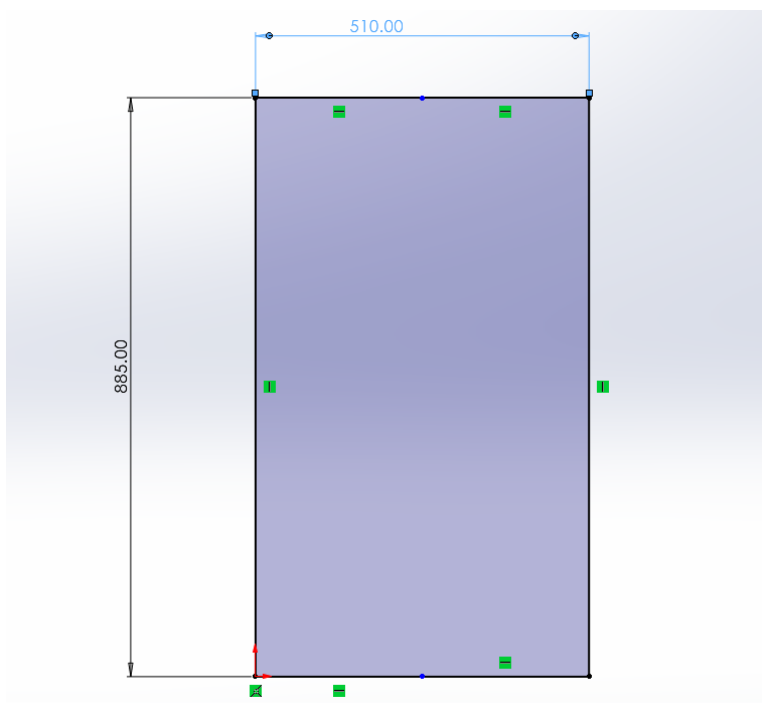


Figure 6-1: Initial sketch of lower half of lid

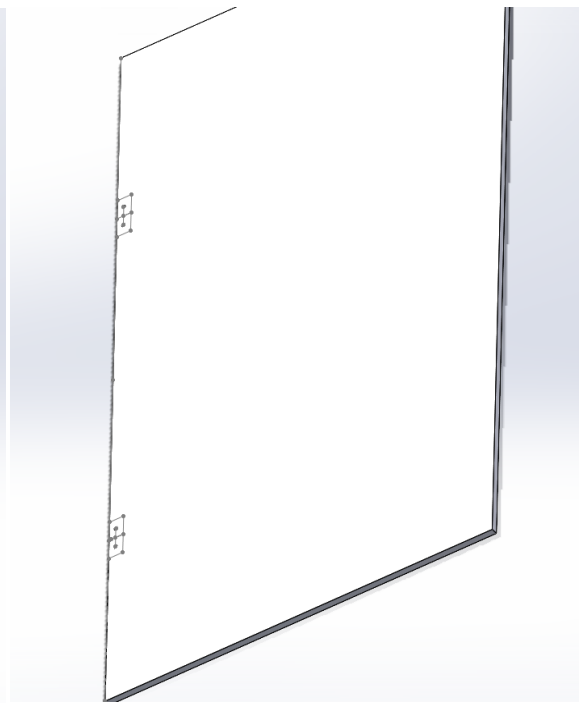


Figure 6-2: Extruded boss of lower half of lid with sketches for hinge placement



Figure 6-5: Up-close shot of tapped holes for hinges

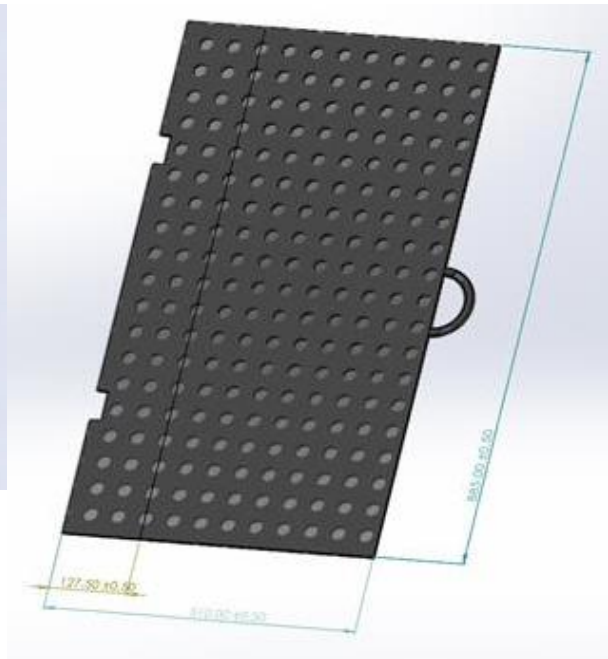


Figure 6-4: Upper half of the lid with handle and cut outs for the hinges

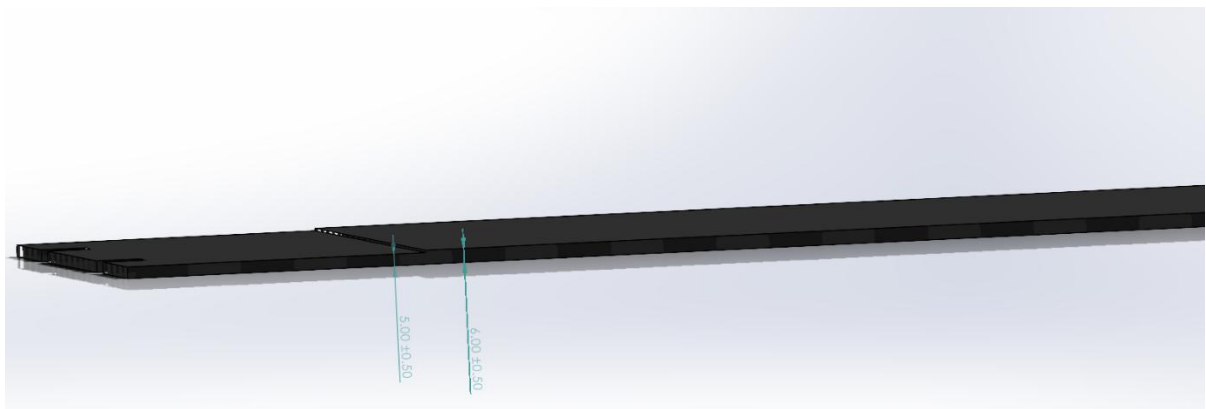


Figure 6-3: isometric view of the upper half of the lid with its two levels of thickness to create buffer zone

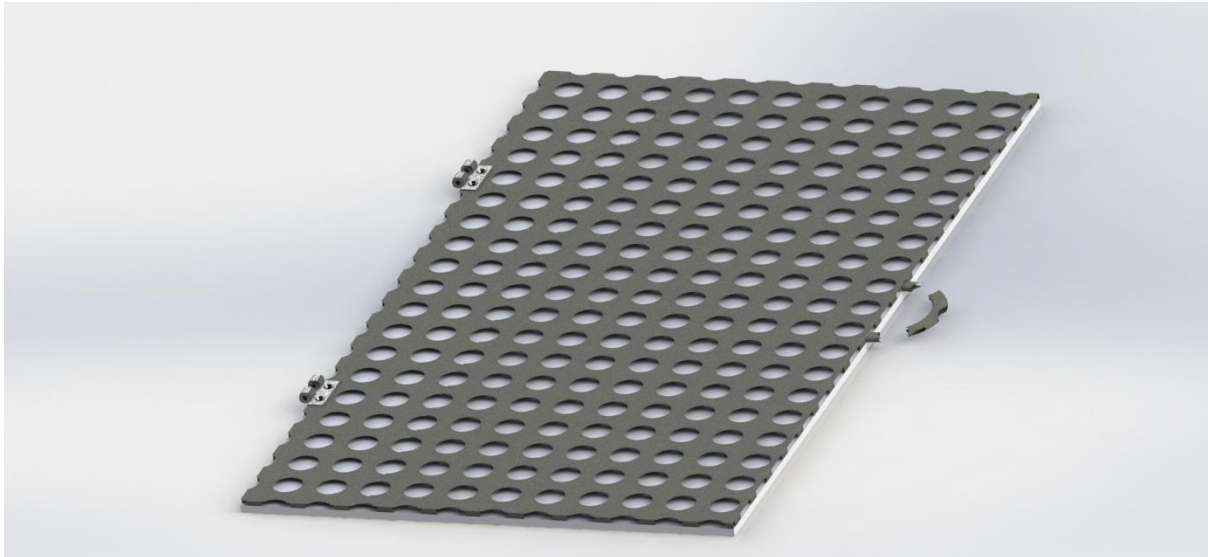


Figure 6-6: First assembly of the first quarter part of the lid.

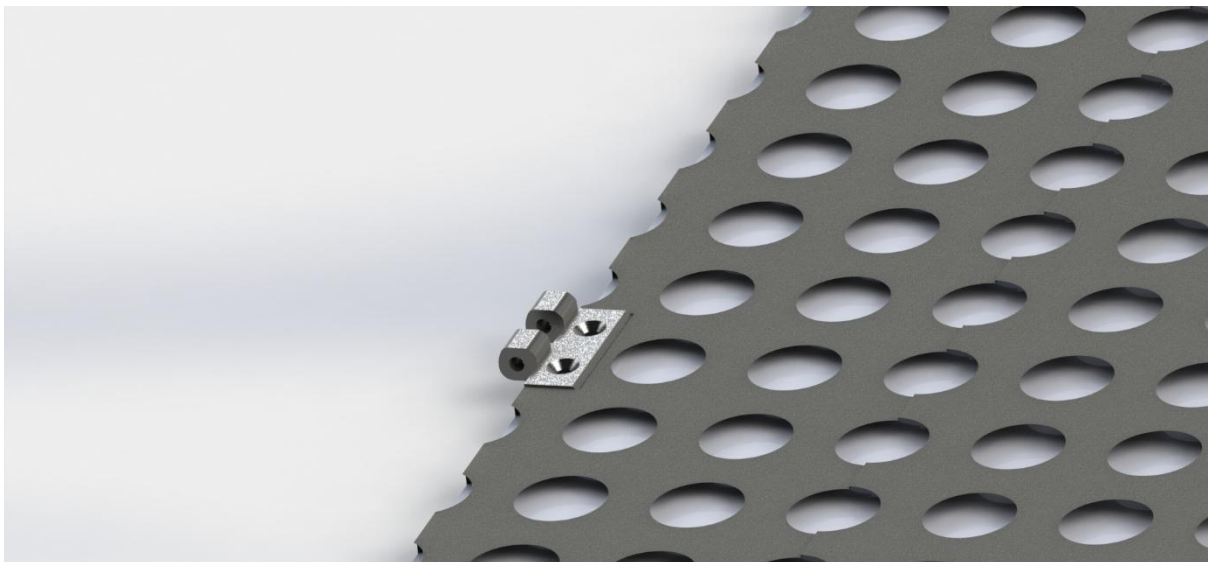


Figure 6-7: Close-up of how the hinge will sit in the upper half and screwed into the top half

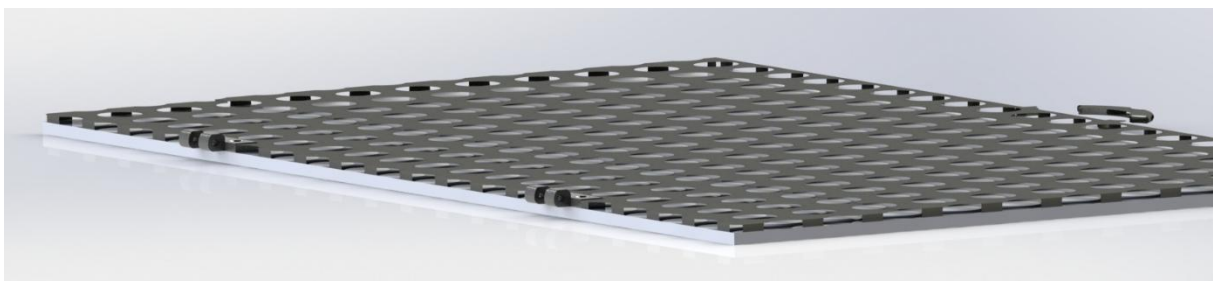


Figure 6-8: isometric shot of the quarter lid assembly.

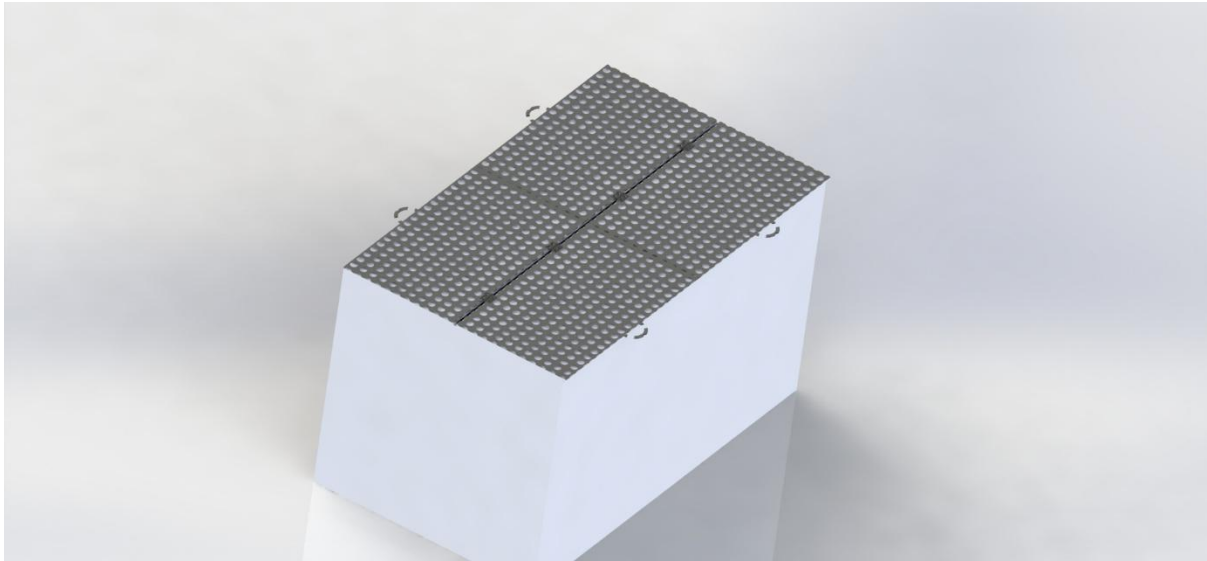


Figure 6-11: Render displaying the overall tank and tank lid with both halves of the tank lid connected via hinges.

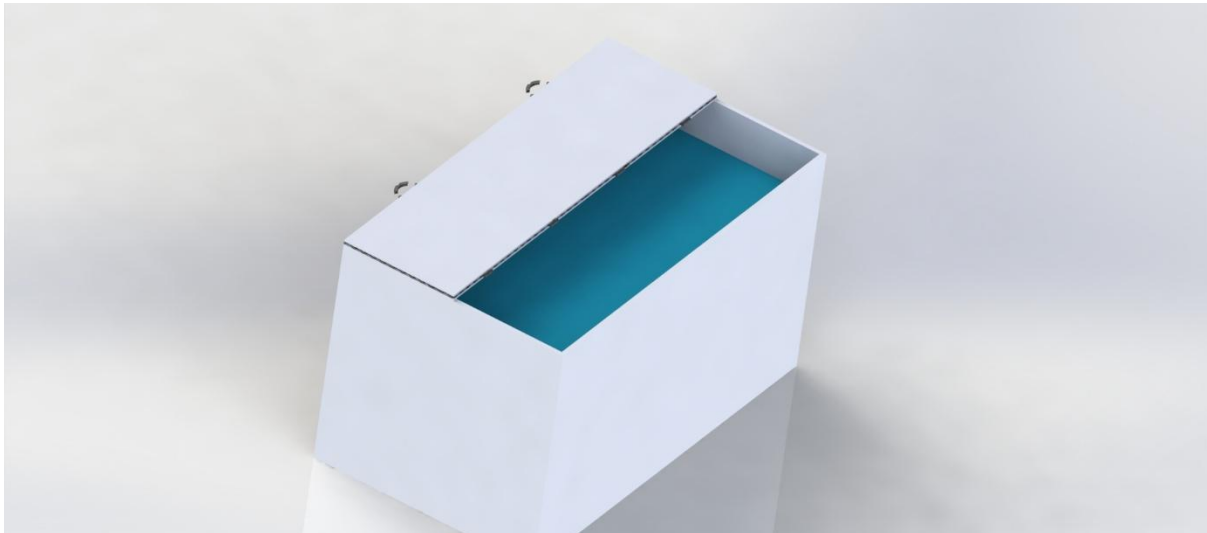


Figure 6-9: Tank with lid folded and ready to be removed one half at a time.



Figure 6-10: Tank with lid fully removed.

7 Technical Drawings

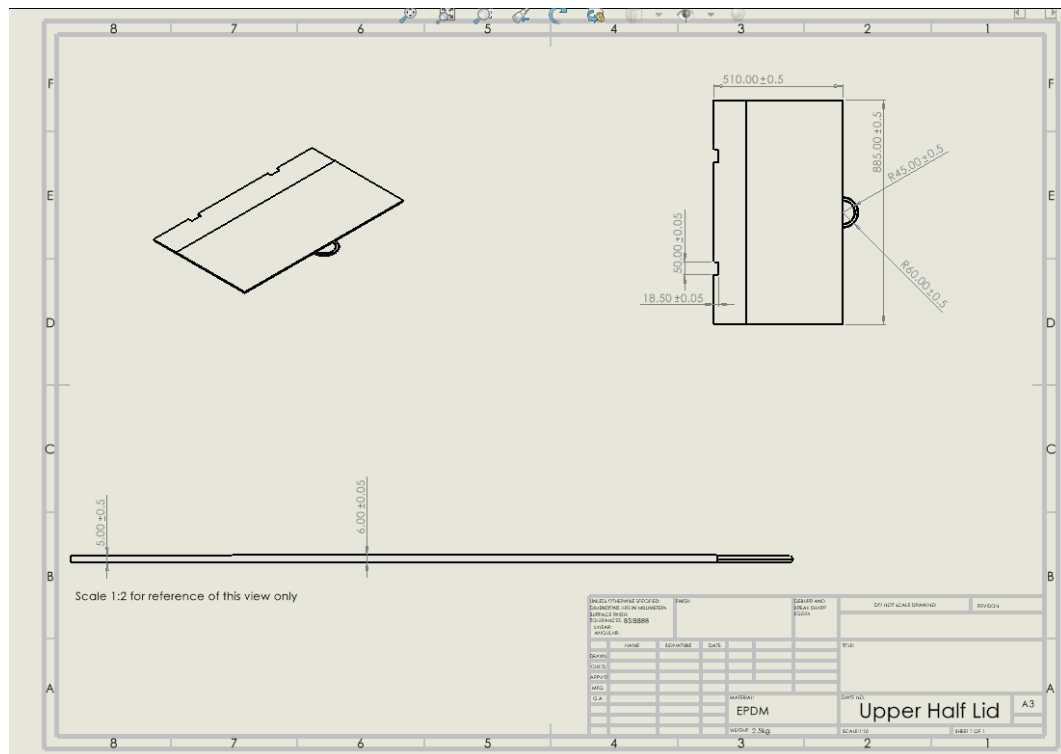


Figure 7-1: Technical drawing of upper quarter of the lid.

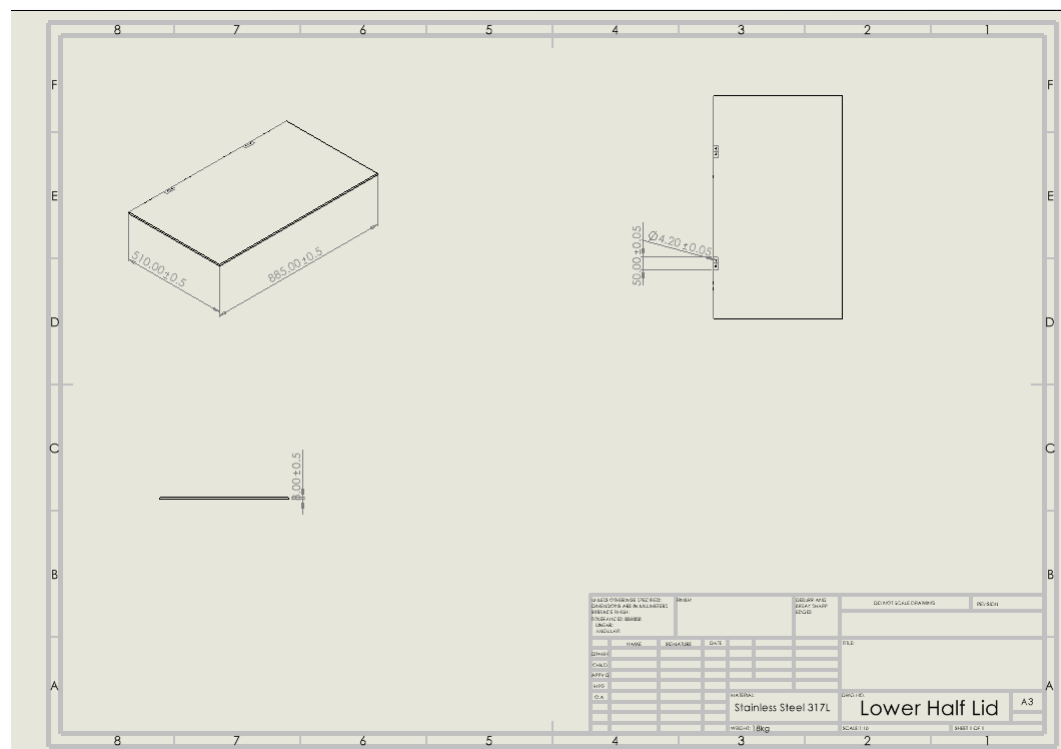


Figure 7-2: Technical drawing of lower quarter of the lid.

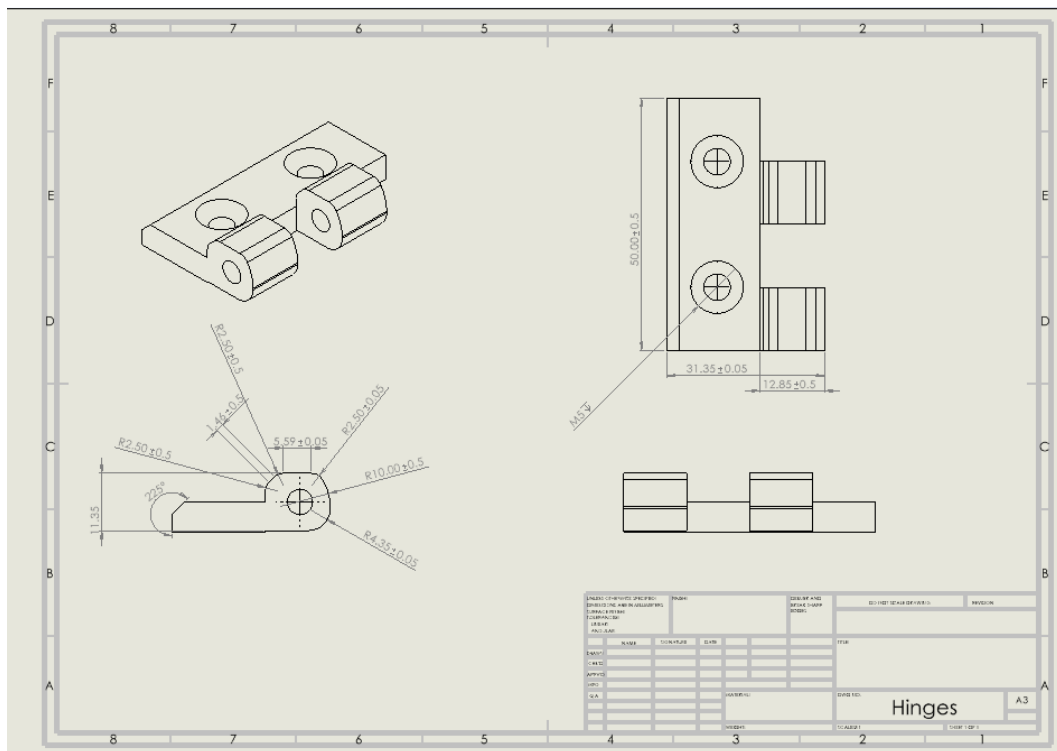


Figure 7-3: Technical drawing of the hinge (Tech Design Hut 2021)

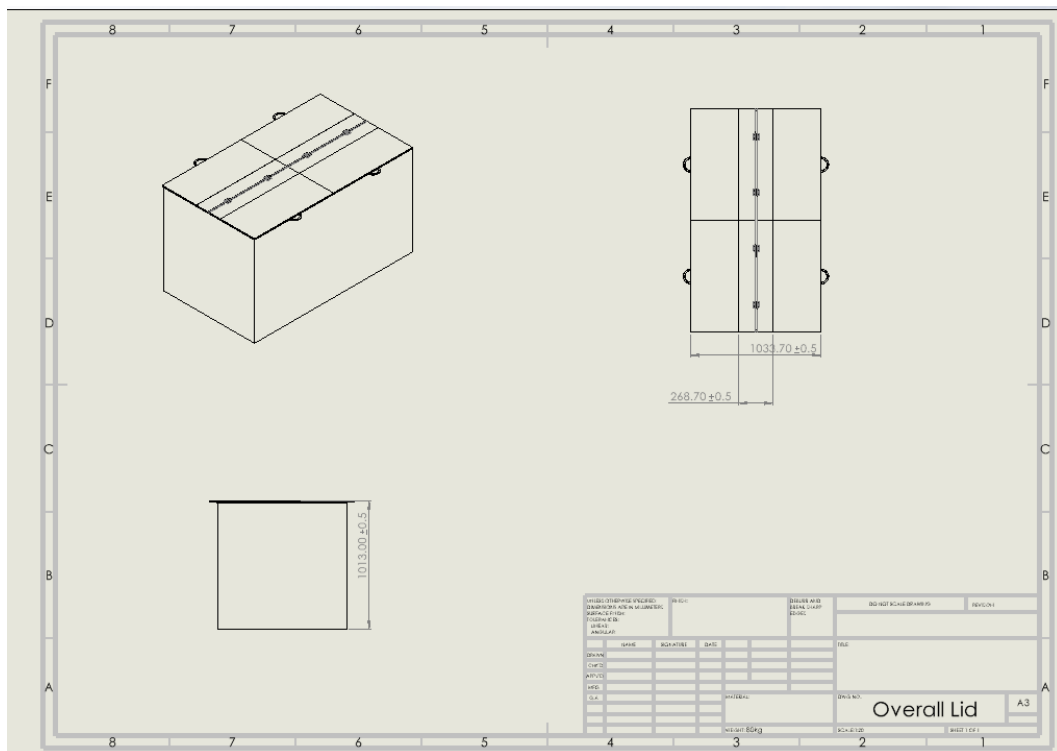


Figure 7-4: Technical drawing of the overall lid attached to the tank.

8 Manufacturing

To manufacture this product, it would include 3 main processes that differ across the individual components. The three main components being the bottom half tank lid which will cover overall the main body of the tank, the upper half which also has a built-in handle, and the hinges. Firstly, the hinges are standardised with only two separate parts being the shaft and the hinge itself this makes produced the hinges much cheaper and easier due to their low complexity. The lower half of the lid is also a very simple design of essentially a rectangle with four holes drilled and tapped for an M5 bolt which will be very easy to make. Lastly the upper half of the lid will also be quite simple to produce as it has the same overall dimensions as the lower half but features two different thicknesses in the upper to produce a buffer for the hinges. The handle has been added onto the side of the upper half as well as two cut outs on the opposite side to fit the hinges. This can all be produced by a CNC machine or plasma cutter depending on what is locally available or quickest to produce and recieve.

9 Conclusion & Further Work

For further work, the client having access to a bigger budget could completely transform the designs incorporated and materials chosen for with nickel alloys having more structural integrity and a longer lifecycle but being much more expensive could see a straight swap between the stainless steel for nickel alloy with the only real downside being the increase in cost.

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Granta software for design research