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Chapter 1 - Introduction

Manufactured aluminium components are anodised by immersing them into stainless-steel tanks containing a 30% sulphuric acid solution heated to 25°C. With safety being paramount, a removable lid made from 5mm thick stainless steel is placed on top when the tanks are not in use. The engineering problem at hand lies with the design of the lid. To add, the lid is heavy and requires two people to lift and position correctly. This procedure poses a significant health and safety risk; therefore, I have been tasked with designing a new lid, with the intension of refining the safety and ease of use.

It is essential that the replacement allows for a single-person operation, while maintaining the same tank dimensions. Additionally, the new design needs to ensure there is adequate overhead clearance to allow aluminium parts to be lowered into the tank. Finally, given the large number, the solution must be practical, scalable, and efficient to implement across multiple locations.

Chapter 2 – Key legislations

The Health and Safety at Work Act 1974 (HSWA) is an extremely important legislation in the UK that defines the responsibilities of both the employer and employee, with the aim of creating a safe work environment. It requires that risks related with workplace activities are acknowledged and dealt with effectively. In relation to the anodisation tank lid, the current design outlines a clear manual handling flaw, as it requires two employees to lift the heavy stainless-steel cover. Looking more in detail, if an employee were to sustain an injury, the employer could be held liable for not maintaining a safe working environment. Overall, this legislation is particularly applicable because it mandates that practical steps must be taken to reduce risks. (legislation.gov.uk, 1974)

In addition, the Manual Handling Operations Regulations 1992 refers to tasks that involve lifting, carrying, and moving heavy objects. These regulations stipulate that employers must evaluate the risks of manual handling and implement measures to eliminate or minimize them. On top of that, the current tank lid design forces employees to perform a difficult lift manoeuvre, increasing the likelihood of injuries. As this problem influences multiple tanks across the facility, finding a solution that reduces strain and allows safe single-person operation is essential for compliance with manual handling safety standards. (HSE, 2016)

Chapter 3 – Specification

Specification Point:	What does this mean?	How will we meet this point?
Aesthetics	The product must be aesthetically pleasing, meaning it must not look out of place with the design of the tank.	To ensure the lid is sleek-looking, I will create multiple designs with the intention of making them simple and fitting to match the environment.
Cost	The product must be cost-effective to manufacture due to the number of units required.	To make sure we achieve our aim, the components must be readily available to purchase, as bespoke parts are more costly.
Customer	The specific target audience of this product is an anodising manufacture.	To meet our target audience, I will design and create a product that appears professional and fulfills its function of covering the anodising tanks when not in use.
Size & Weight	The end product must be as compact and lightweight as possible to align with the following dimensions: Overall Length = 1770mm Width = 1020mm Height = 20mm	To satisfy the criteria, research will be performed to identify possible solutions that can be incorporated into the design.
Ergonomics & Anthropometrics	The lid design must incorporate ergonomic and anthropometric principles, allowing users to operate it comfortably, safely, and efficiently.	To ensure ease of use, the lid should not be cumbersome; implementing solutions like pivot points or counterweights to evenly distribute the weight will assist in this.
Materials & Components	The product must be made from cost-effective and readily available materials, to maintain a feasible fix.	A range of materials will be reviewed, considering their pros, cons, and functionality, allowing me to determine the optimal choice for the product.
Manufacture	It is a must that the product is made using reliable, accurate and precise manufacturing method.	Thorough research will be carried out to examine various manufacturing techniques and identify the most appropriate one.
Environmental Considerations	The product must minimise the environmental impact during the making process.	To lessen the environmental footprint, reused materials will be utilized where practical and waste will be cut down by implementing CAD software until final prototyping.
Quality Assurance Quality Control	The product must be durable and reliable, ensuring optimal performance and enhancing the effectiveness of the anodising tank	To meet our expectations, we will create and assess multiple design iterations to uncover and resolve any design issues.

Chapter 4 – Time plan

Weeks 1-2

In week 1, I will conduct research and problem Identification by reviewing the existing tank lid design and the I challenges identified. Furthermore, feedback will be collected from the staff on the current lid's usability by creating a questionnaire, its aim will be to gather ergonomic and anthropometric data relevant to manual handling.

In Week 2, I will examine alternative materials and mechanisms that could refine the lid's functionality and safety. To add, it will also involve determining the design limitations, such as weight, durability, and clearance specifications.

Weeks 3-4

In week 3, a range of design solutions will be brainstormed, such as Hinged style lids and counterbalanced systems. Initial design concepts will be created and reviewed for feasibility, safety, and operational efficiency.

Furthermore, week 4 will see me fine-tuning the top design idea and developing an initial CAD model to represent the solution.

Weeks 5-8

Throughout weeks 5-6, the CAD designs will be finalised, simulations for material strength and durability will be executed, and a cost analysis will be undertaken to verify the designs' practicality also.

Moreover, in weeks 7-8, a final version of the prototype will be built with the chosen materials and manufacturing processes.

Weeks 9-10

In Week 9, further ergonomic and safety assessments will be conducted, any necessary refinements to improve functionality and safety will be made based on this feedback.

By Week 10, the final design will be validated against company safety and operational standards.

Weeks 11-12

Week 11 will be dedicated to creating and manufacturing an assembly guide. The resources required for full-scale production will be identified, and logistics for distributing.

By Week 12, the final design will be presented to stakeholders for approval.

Weeks 13

Finally, in Week 13, a review will be conducted. This will include documenting findings and lessons learned from the design and implementation process. (Visme, 2020)

Chapter 5 – Relevant research

Lid dimensions:

- Length = 1770 mm = 1.77m
- Width = 1020 mm = 1.02m
- Thickness = 5 mm = 0.005m

Density of stainless steel $\approx 8000 \text{ kg/m}^3$

Volume = Length $\times$ Width $\times$ Thickness

$$V = 1.77 \times 1.02 \times 0.005$$

$$V = 0.009027\text{m}^3$$

Mass = Volume $\times$ Density

$$M = 0.009027\text{m}^3 \times 8000 \text{ kg/m}^3$$

$$M = 72.216 \text{ kg}$$

The original lid weighs 72.216 kg, making it difficult to handle safely. However, the new design will be divided into two sections, meaning each torsion hinge must support at least 36.108 kg, to ensure stability and safe operation.

Fitness Volt indicates that an average untrained man can lift approximately 50 kilograms (110 pounds) in exercises like the squat and bench press. Given that the product's doors weigh 36 kilograms (79 pounds), this is well within the lifting capacity of an average man, suggesting that handling the doors should be manageable for most individuals. (Saini and Griffin, 2024)



A torsion hinge is a combined hinge and lid support that ensures smooth and controlled movements. Furthermore, they prevent the product from slamming shut. The purpose of a torsion hinge is to hold the lid open in any position, providing constant support, very similar to laptop hinges. Torsion hinges are especially useful for trunks and chests. Unlike traditional hinges, torsion hinges offer a convenient all-in-one solution, saving time, money, and installation effort. They are easy to install with minimal measuring required. Torsion hinges can support a variety of lid sizes, offering more flexibility compared to conventional lid supports. (Aconcordcarpenter.com, 2015)

Figure 1 – Torsion Hinge (Rustic, 2025) Weighing only 346g, the torsion hinge is exceptionally lightweight, yet it is capable of supporting up to 45kg of weight (9kg more than the weight of the tank lid). Its design allows for easy installation using either M6 or 1/4 capped screws, ensuring a secure and stable attachment for a wide range of applications. (Reell Precision Manufacturing, 2024) (Rockler.com, 2022)

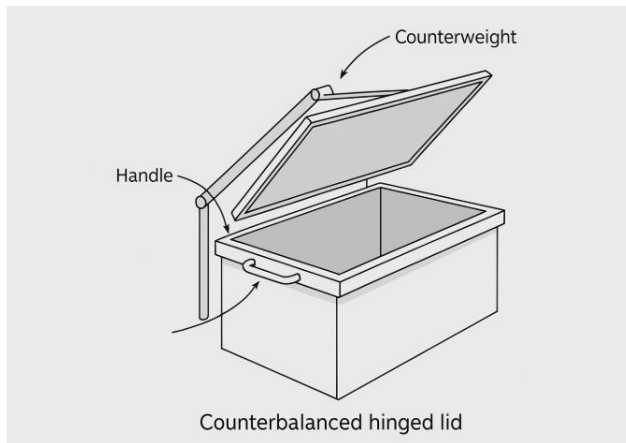


Figure 2 - Counterbalanced Design

This counterbalanced hinged lid design utilizes a counterweight mechanism to assist in lifting and holding the lid open with minimal effort. The lid is connected to a hinge that allows it to pivot smoothly, while an attached counterweight offsets the lid's weight. As the lid is lifted, the counterweight moves in the opposite direction, reducing the force required to open and hold it in place. This system ensures the lid remains stable in an open position without the need for additional support mechanisms like gas struts or torsion hinges. This counterbalance system offers several benefits, including smoother

operation, increased safety by preventing accidental slams, and improved efficiency by minimizing the effort needed to lift heavy lids. (callum whitelaw, 2016) In industrial applications, counterbalance hinges can be designed to handle door panels weighing between 15 and 500 lbs, approximately 6.8 to 227 kg. (Stroud, 2020)

Designing a counterbalanced arm for a 72/73kg lid is a highly complex and resource-intensive task. It requires precise engineering calculations to ensure the counterbalance mechanism effectively neutralises the lid's weight throughout its range of motion. Specialized materials like aluminium or carbon fibre must be used to maintain strength while minimizing additional weight, further driving up costs. Given these complexities, the endeavour may be impractical and costly compared to alternative, simpler solutions. (Knapp, 2022)

Pricing

Design 1: Folding Torsion Design

Parts/Components:	Quantity:	Price:	Link:
Torsion Hinge	4	£30.10 Each Total = £120.40	82mm x 92mm Heavy Duty Stainless Steel Door Hinge Vital Parts
Handles	2	£11.14 Each Total = £22.28	Knurled Pattern Cabinet Pull Handle - Stainless Steel Effect G Johns & Sons
Stainless Steel M6 Bolts	16	£4.50 Each Total = £72	Stainless Steel Flanged Hex Head Bolt M6x(1.00mm)x12mm Pro-Bolt

(Least number of components, least likely to mechanical fail and cheapest to manufacture)

Design 2: Scissor Folding Torsion Design

Parts/Components:	Quantity:	Price:	Link:
Torsion Hinge	8	£30.10 Each Total = £240.80	82mm x 92mm Heavy Duty Stainless Steel Door Hinge Vital Parts
Handles	2	£11.14 Each Total = £22.28	Knurled Pattern Cabinet Pull Handle - Stainless Steel Effect G Johns & Sons
Stainless Steel M6 Bolts	32	£4.50 Each Total = £144	Stainless Steel Flanged Hex Head Bolt M6x(1.00mm)x12mm Pro-Bolt

(Lots of Components and more expensive to manufacture than Design 1)

Design 3: Counterweight Design

Parts/Components:	Quantity:	Price:	Link:
Design & Modelling	N/A	£1,000 - £5,000	N/A
Material - Aluminium	N/A	£5 - £10 (Per Kg)	N/A
Fabrication	N/A	£500 - £2,000	N/A
Testing & Quality Assurance	N/A	£200 - £500	N/A
Total	N/A	£1,950 - £8,000	N/A

Chapter 6 – Sketches

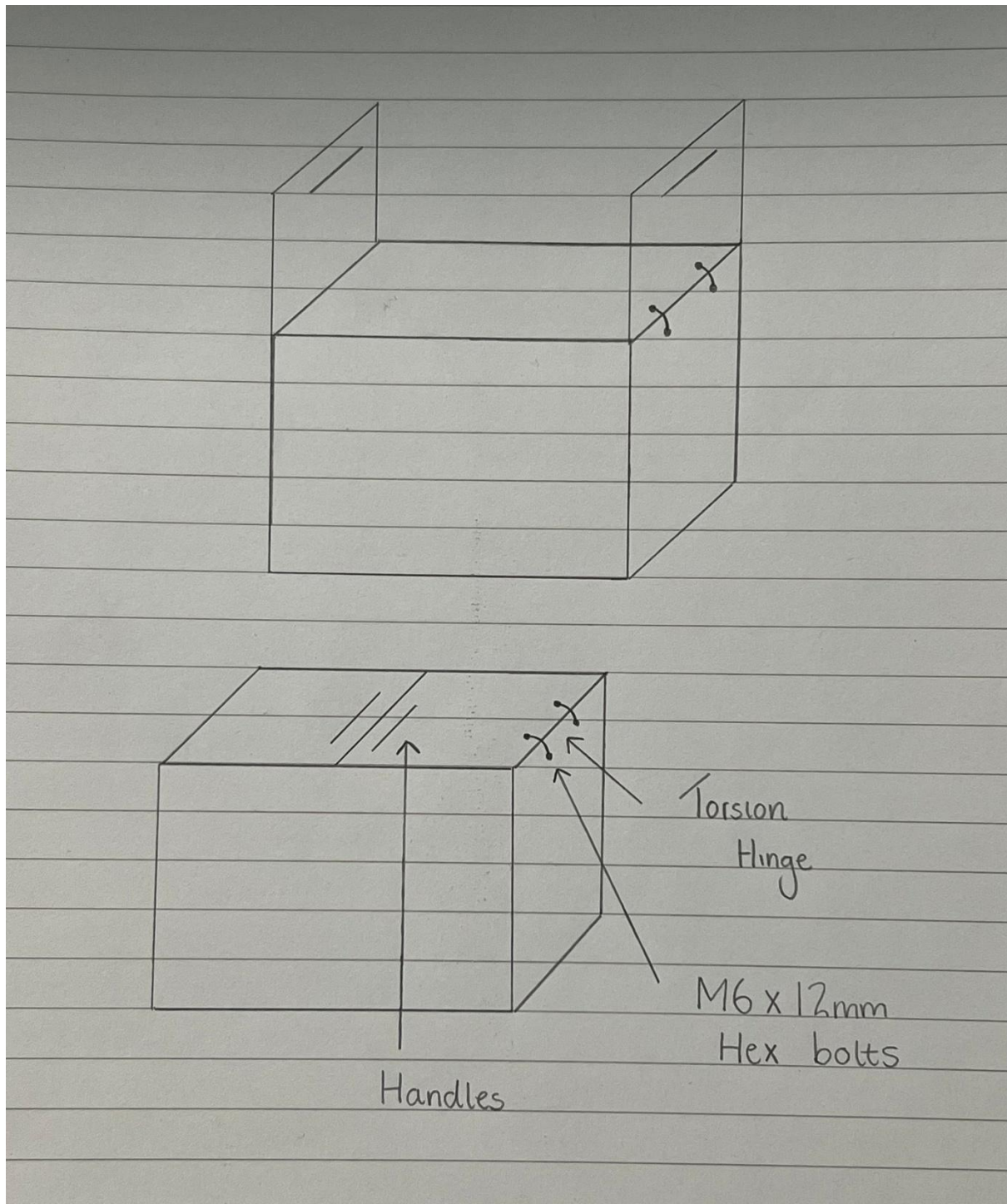


Figure 3 - Torsion Hinge Design 1

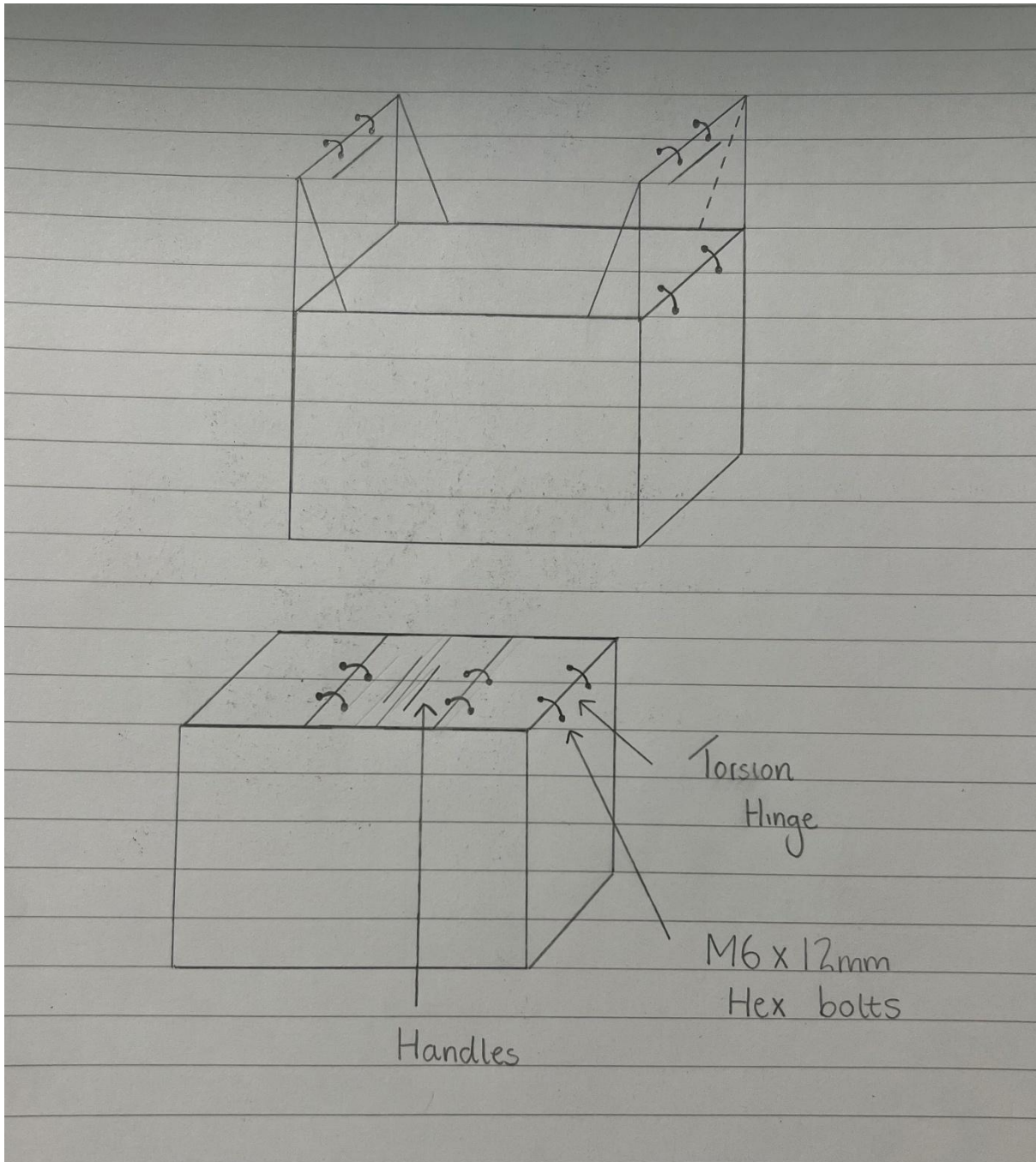


Figure 4 - Scissor Torsion Hinge Design 2

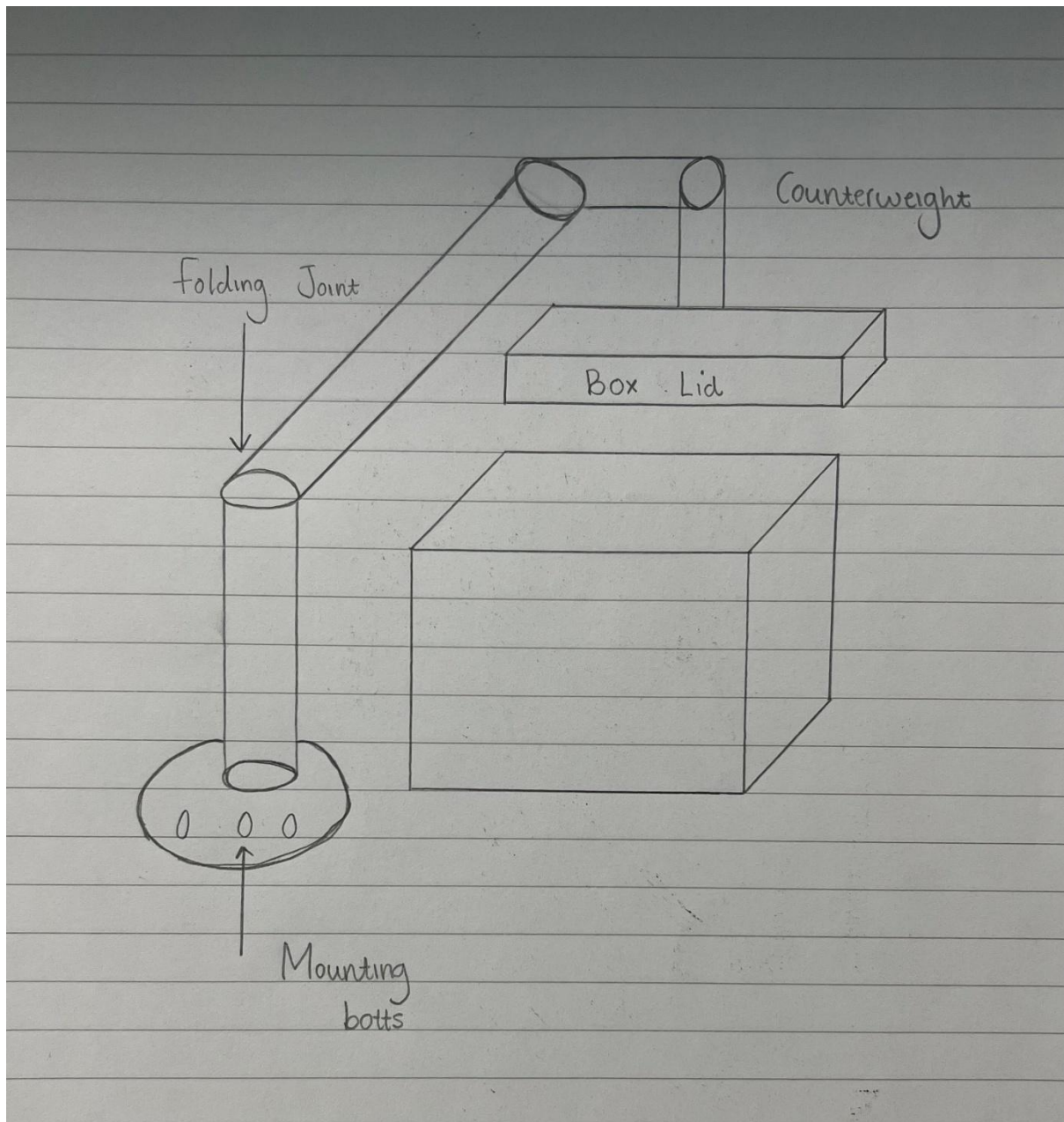


Figure 5 - Counterbalanced Design 3

Chapter 7 – CAD model

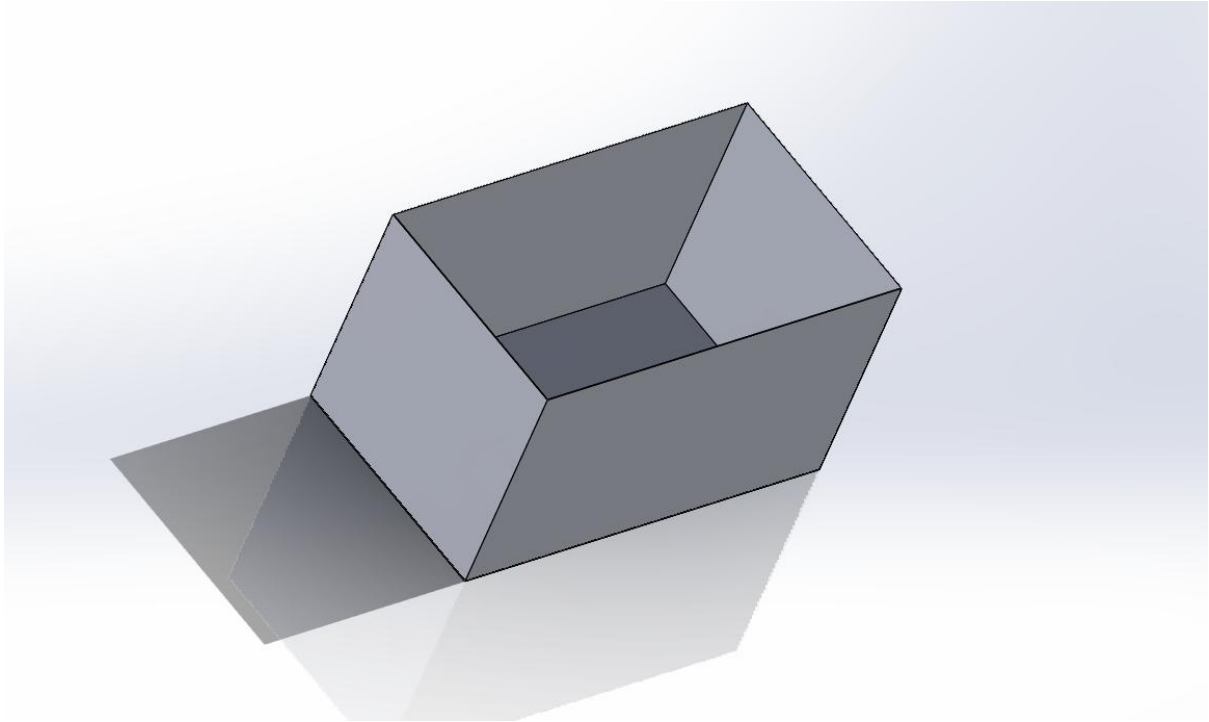


Figure 6 - Tank

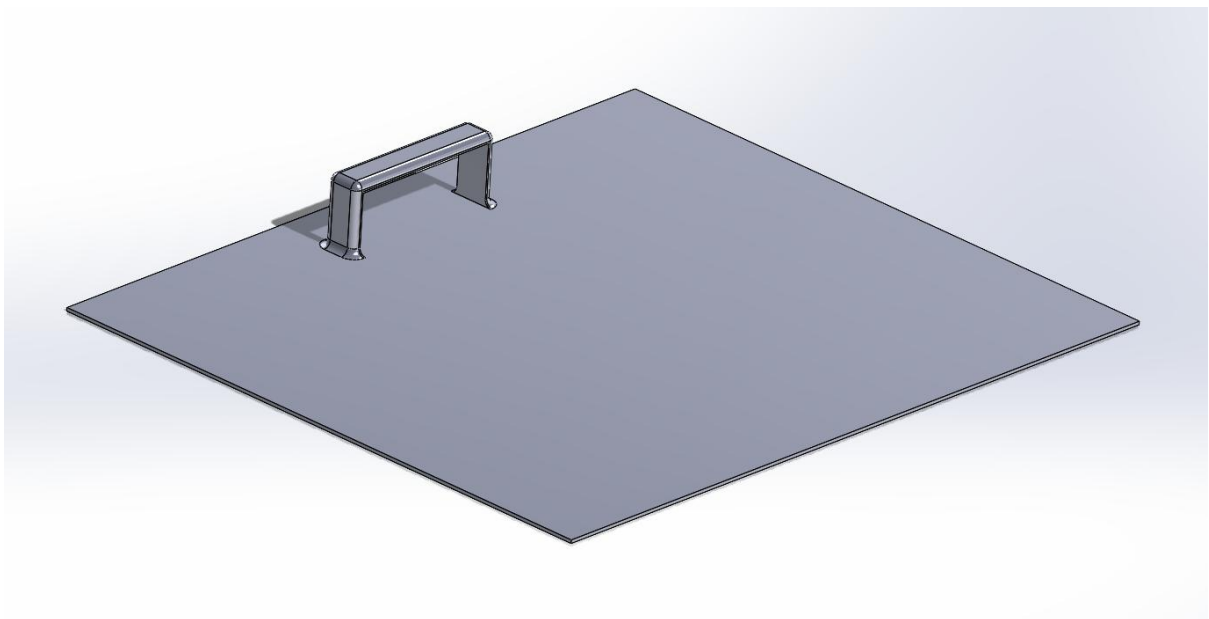


Figure 7 - Tank Modified Door

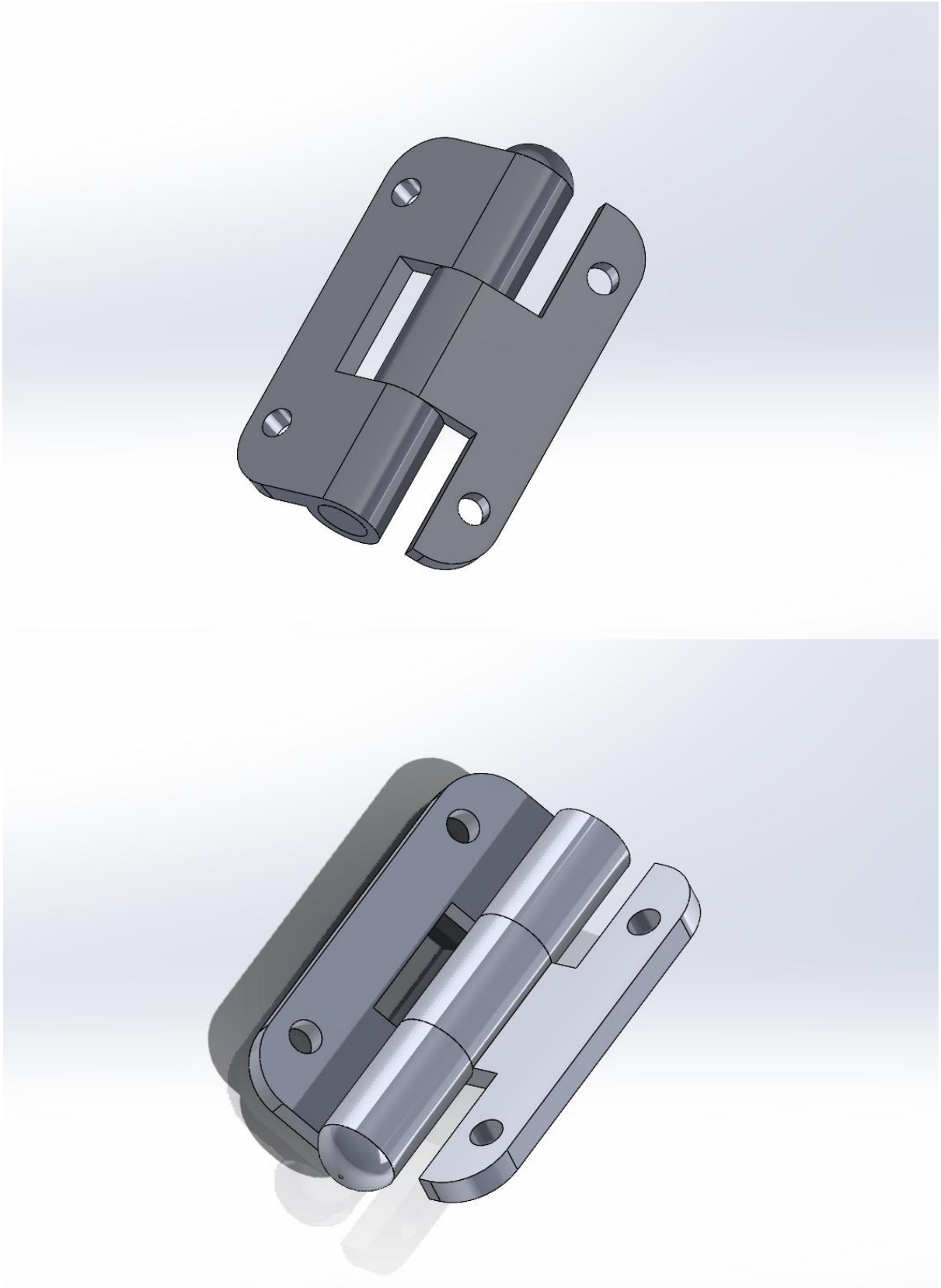


Figure 8 - Complete Torsion Hinge Design

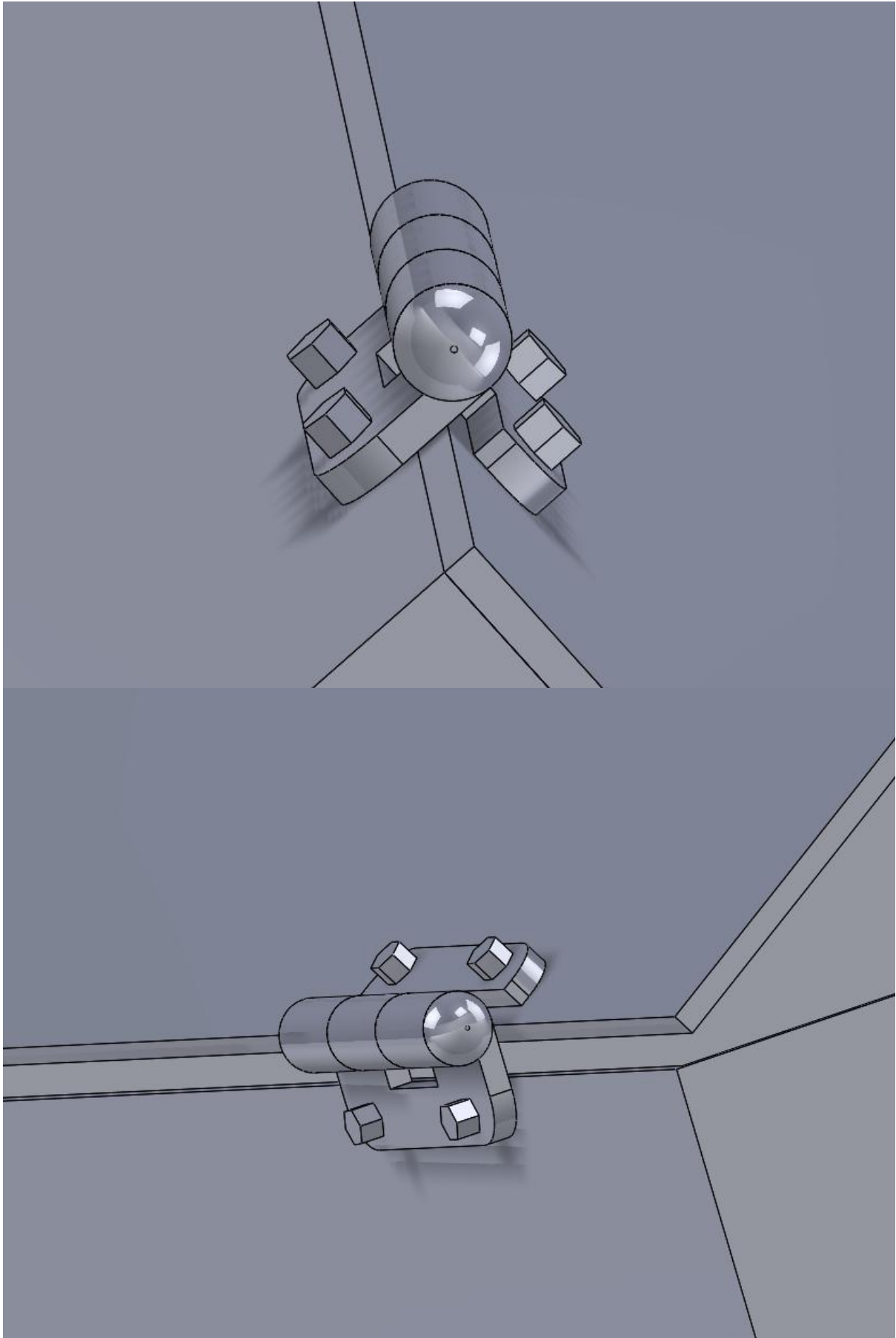


Figure 9 - Torsion Hinges Fitted

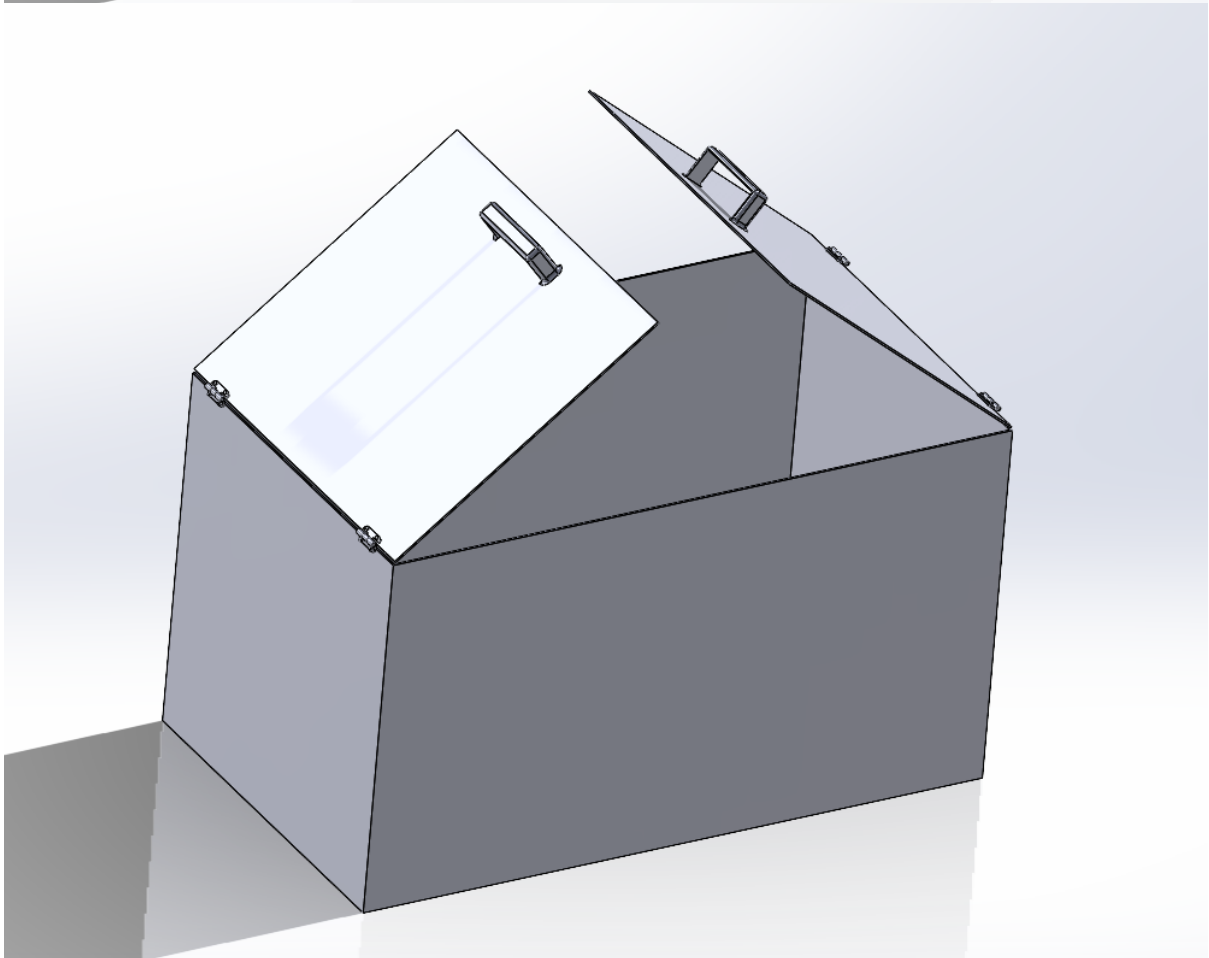
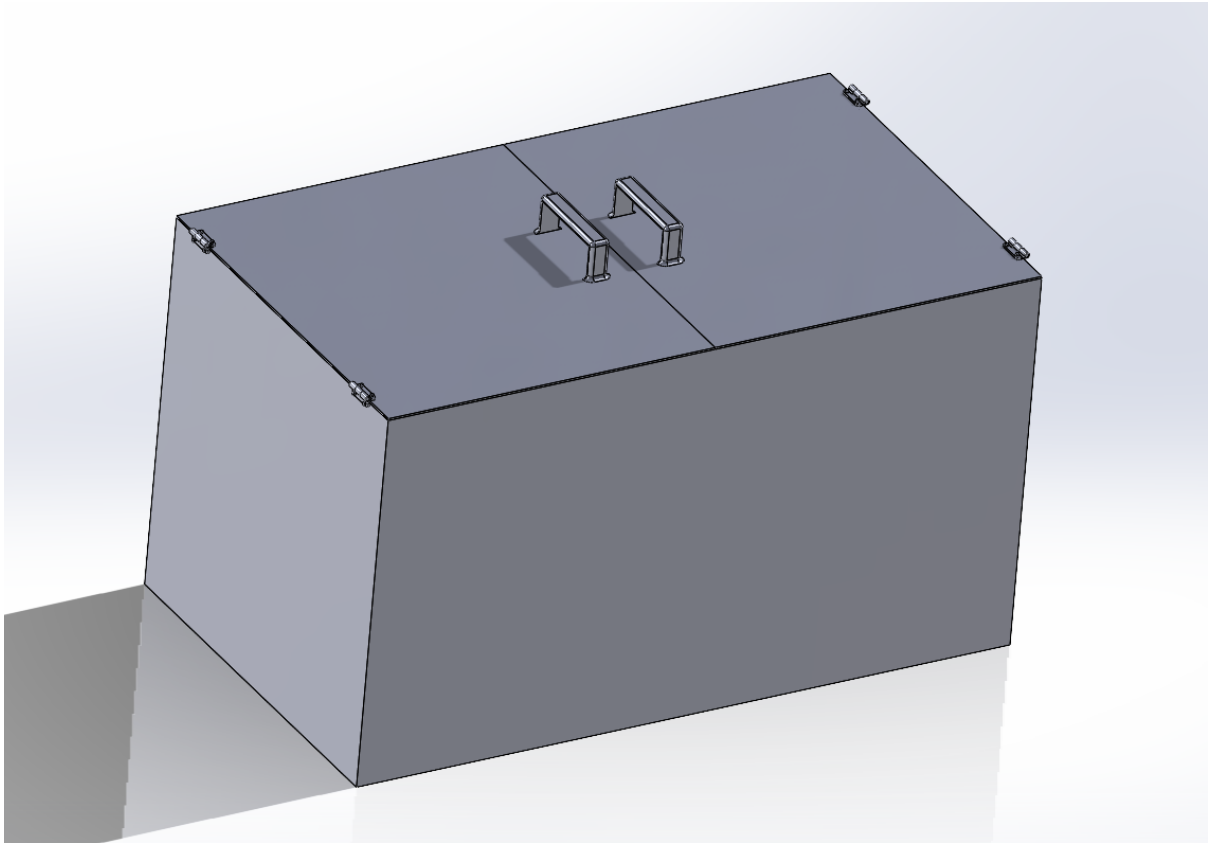


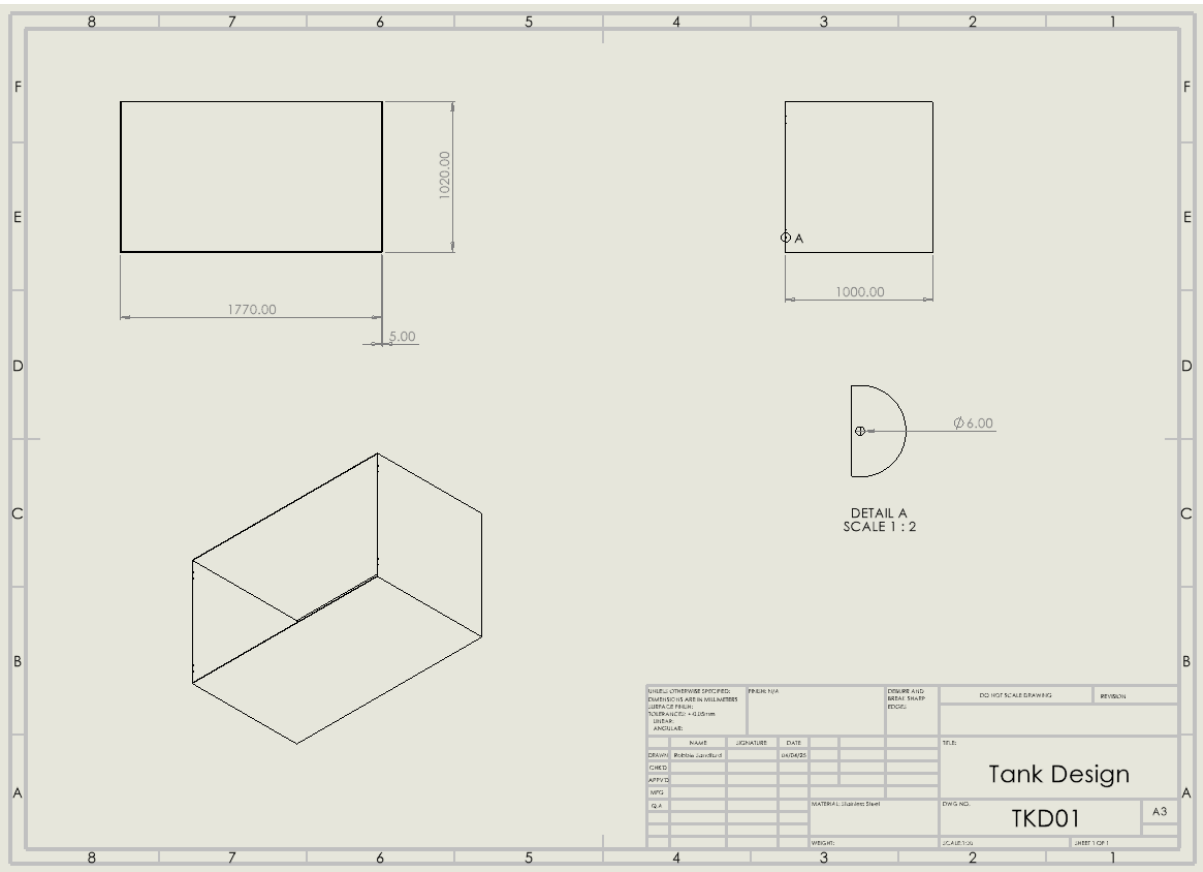
Figure 10 - Completed Design

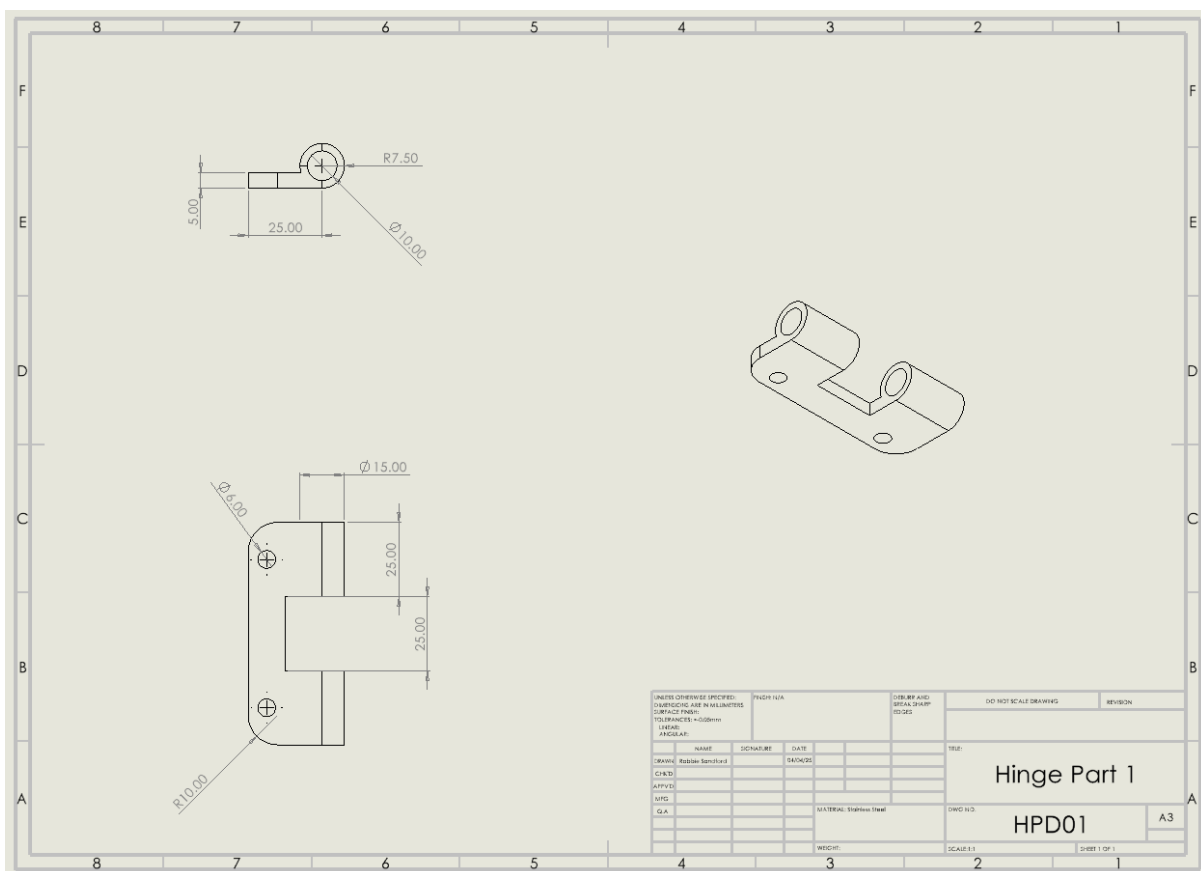
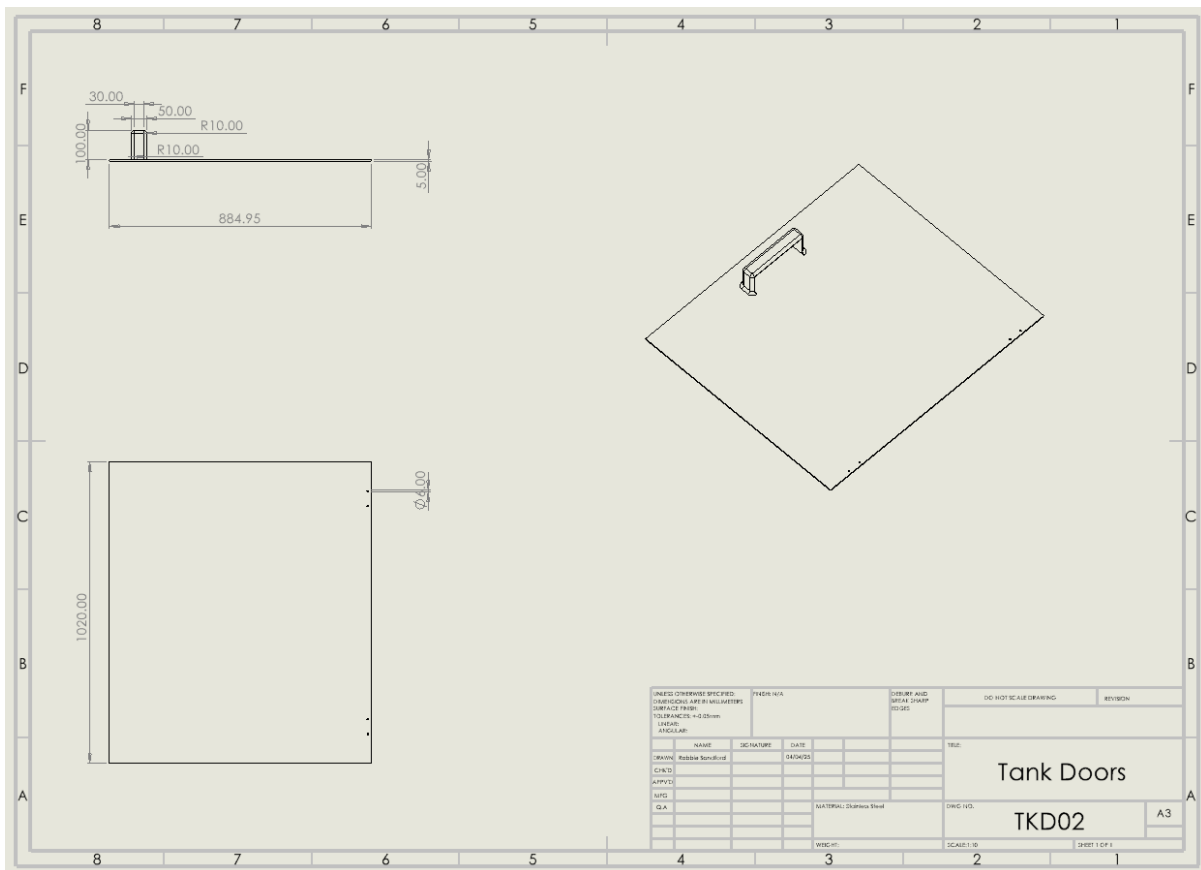
Chapter 8 – Fully dimensioned technical drawings (BS8888)

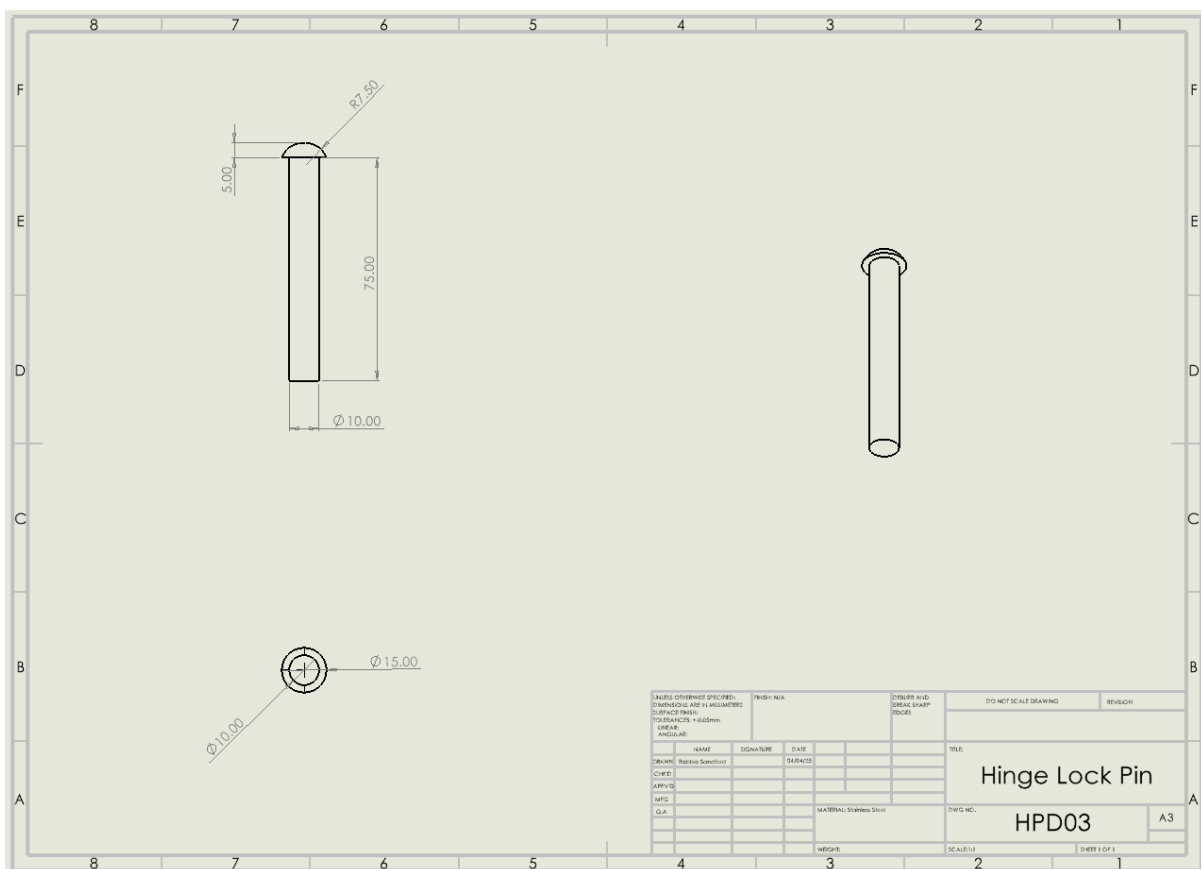
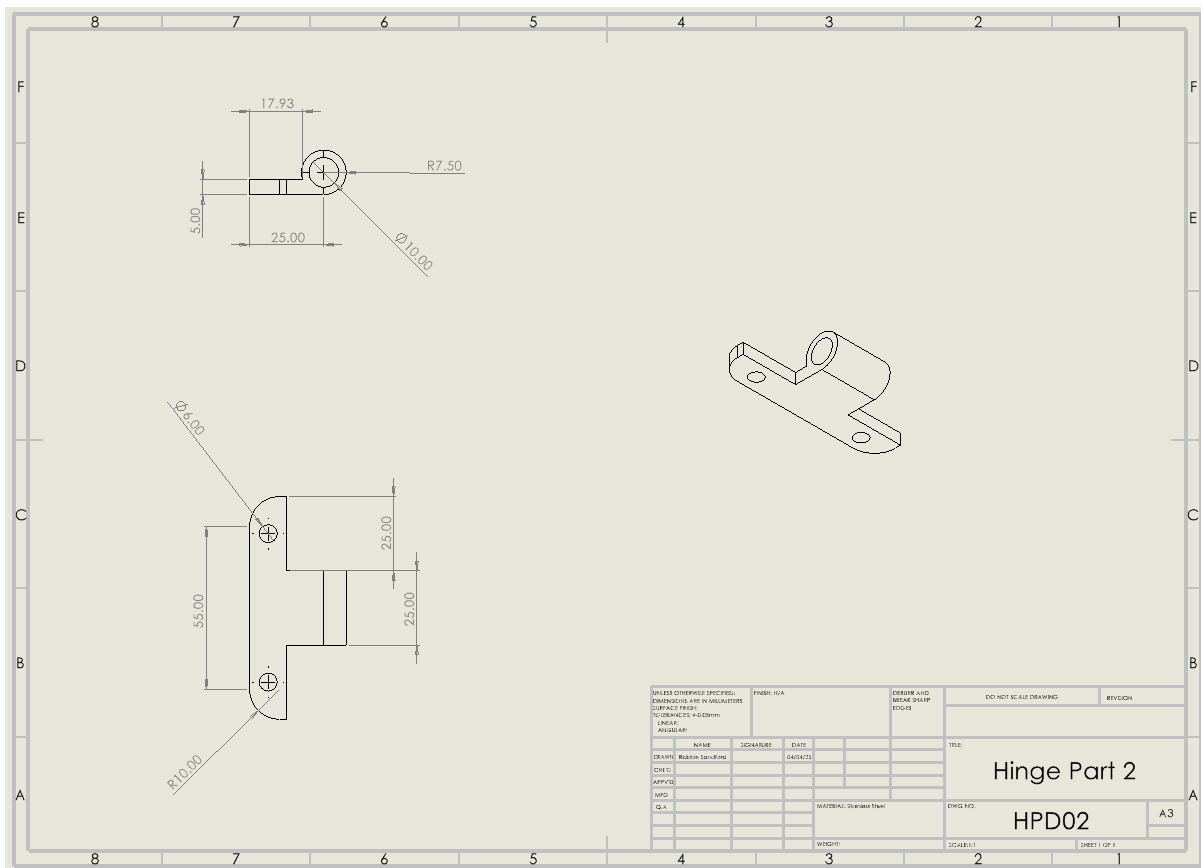
In order to ensure the precise fit and functionality of the modified solvent tank lid, a 0.05mm tolerance has been selected for key components involved in the adjustment process. Given that the tank sides will be threaded to accommodate M6 bolts, maintaining tight tolerances is crucial to ensure a secure and stable fit for the cast torsion hinges.

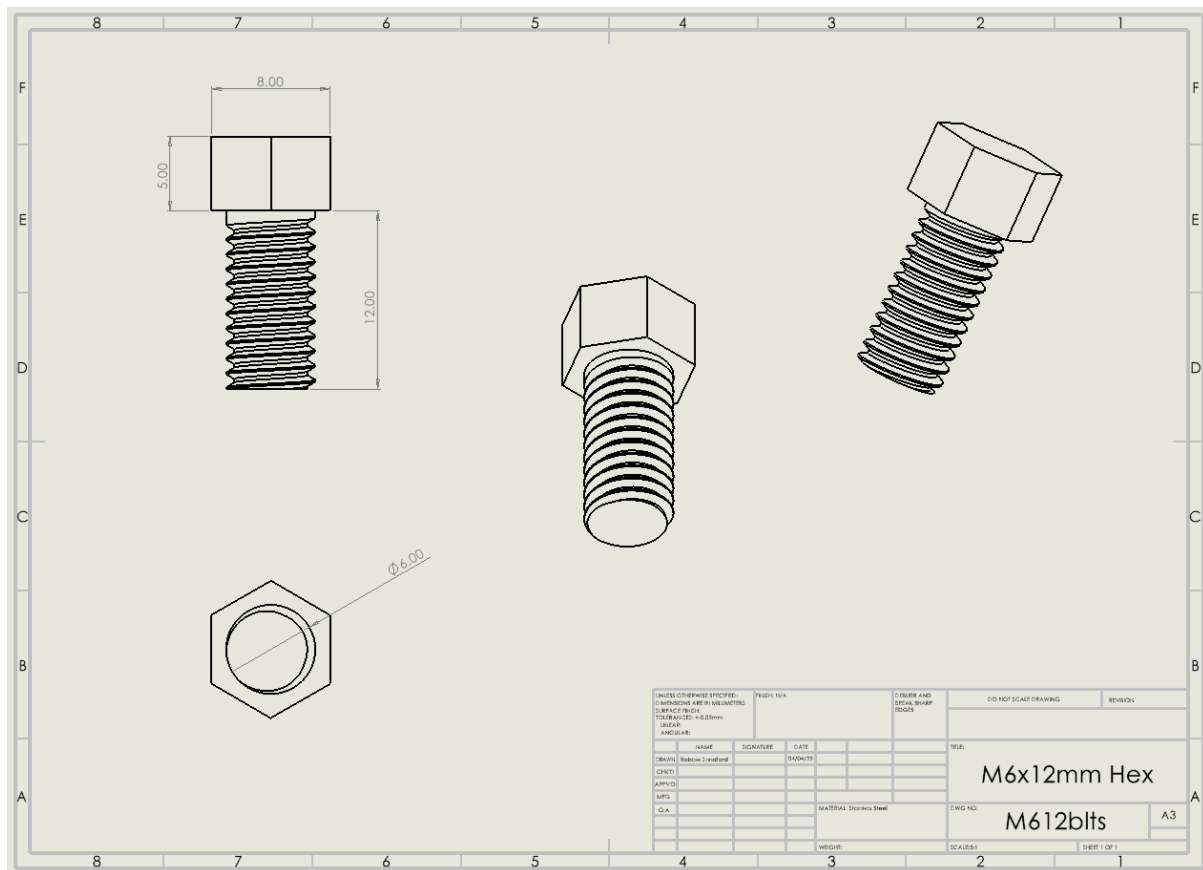
A tolerance of 0.05mm allows for proper thread engagement while preventing excessive looseness or misalignment, which could compromise the durability and function of the hinge system.

By implementing a 0.05mm tolerance, the design maintains high-quality assembly, minimizes rework, and ensures long-term reliability without unnecessary production costs.









Chapter 9 – Justification for design choice

I have Chosen Design 1 (*Torsion Folding Hinge*) for the final design of the solvent tank lid, as it offers a sustainable solution by reducing waste through the reuse of the original stainless-steel lid. Instead of manufacturing completely new lids, which would demand additional raw materials and expensive production resources, the current 5mm thick stainless-steel lid can and will be modified.

Furthermore, this involves cutting the original lid (with an overall length of 1770mm) in half to create two 885mm doors (including $\pm 0.05\text{mm}$ tolerance). This modification enables the original lid to be reused efficiently, greatly reducing material waste and promoting an eco-friendlier design approach.

Additionally, the two doors will be fastened directly to the tank via four cast torsion hinges; two on each side. I have specifically chosen torsion hinges, as they are great for this application and offer smooth, precise movement, enabling the doors to open and close effortlessly without requiring excessive force.

To support the new hinge system, the tank will need minor adjustments. In particular, the tank will need to have threaded holes to accommodate the M6x12mm bolts, which will firmly secure the hinges. These adjustments are minimal and will not affect the overall size or material of the tank, which must stay the same to remain compatible with the anodisation process.

This solution addresses the main issues raised by staff and health and safety officers regarding the difficulty of handling the current weighty lid, allowing a single person to operate the lid, improving both safety and ease of use. Not to mention, the lighter, more accessible doors can be opened and closed with less effort, reducing the risk of strain or injury during the lifting and securing process.

Overall, the design minimizes waste by recycling the original lid, improves safety and maintains the structural integrity of the tank. To create my design would cost £113.24 which is reasonable compared to the counter balanced design, especially when you take into consideration; that several hundred have to be made. The use of cast torsion hinges and minimal modifications to the tank ensures that the design meets both the safety requirements and operational needs, offering a sustainable, cost-effective, and user-friendly solution for the facility.

Chapter 10 – Manufacturing processes

Torsion Hinges

Torsion hinges are often made using a wide range of engineering processes, all depending on their strength, material, and production needs.

- Casting is commonly used to create hinges in large quantities with complex shapes.
- Machining, including milling, drilling, and grinding, is used for precision parts that need tight tolerances.
- Stamping and press forming are cost-effective methods for shaping sheet metal hinges quickly.
- For heavy-duty applications, forging is used to strengthen the hinge by shaping heated metal under high pressure.

SUS304 (AISI 304) stainless steel contains 18% chromium and 8% nickel. It offers a good corrosion resistance and strength. Furthermore, it's widely used in various applications due to its balance of durability and cost-effectiveness.

On the other hand, SUS316 (AISI 316) is similar to AISI 304 but with an addition of 2% molybdenum, enhancing its resistance to corrosion, especially against chlorides and marine environments.

In terms of my application, SUS304 is the better choice due to its strong corrosion resistance, durability, and cost-effectiveness. (Tan, 2021)

Chapter 11 – Conclusion and further work

In conclusion, the folding hinge design proved to be highly effective, with all components fitting together seamlessly, this was shown as the tolerances were precisely well-calculated, ensuring smooth operation and eliminating any issues with interference. The overall assembly process was straightforward, and the design functioned as intended, providing a reliable and practical solution for the tank cover.

The main key achievement of this design was the precise alignment of all components, which contributed to its ease of use. The consideration of tolerances meant that all parts worked together without excessive friction or misalignment. Additionally, the chosen materials and assembly methods supported the durability and longevity of the system.

For future improvements, one potential enhancement would be to extend the hinges. This modification would allow for the use of a longer and larger-diameter bolt, increasing the overall strength and durability of the hinge mechanism.

This change could also improve load distribution, reducing wear over time. By making this adjustment, the design could become even more robust and capable of handling extended use in demanding environments while maintaining its efficiency and functionality.

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