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Engineering Problem

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Introduction

Anodization is an important process in manufacturing aluminium products, it enhances corrosion resistance, durability, and overall aesthetic. The design of the tank plays a critical role in process efficiency and safety. This report dives into the processes behind a complete redesign of a lid, taking into account key restrictions in terms of cost, constraints, materials, and production.

Design Brief

Client Brief

The component that requires a complete redesign is the lid from an aluminium anodization tank. This tank is currently fitted with a lid that requires two people to remove; staff has complained that it is very difficult to remove and in doing so many health and safety rules are broken. The redesign must have the same dimensions as the original. It must also be operated by one singular person whilst abiding with all health and safety regulations. The lid can be altered however, the material must remain the same.

Legislations

Engineering and safety standards

BS EN ISO 7599:2018: Specifies requirements for anodised aluminium coatings

BS EN 1090-2:2018: Covers structural steel and aluminium components

BS 5306-3:2017: Fire safety standard for workplaces handling chemicals (BSI, 2025)

Environmental and Chemical handling regulations

REACH (EU Regulation 1907/2006): Compliance with chemical safety for substances used in anodization (Commission, 2007).

Health and Safety regulations

COSHH (Control of Substances Hazardous to Health) Regulations 2002: Handling anodizing chemicals (HSE, Health and Safety Executive, 2002).

The Workplace (Health, Safety and Welfare) Regulations 1992: Ventilation and structural safety requirements.

Provision and use of work equipment Regulations 1998 (HSE, 1998)

Manual handling at work act 1992: safe use of moving heavy items.

Specification

This lid redesign has to have a few key characteristics in mind, the main one being that it has to have complete clearance above the tank due to the aluminium parts needing to be lowered into the tank. Another is the material choice, it must be lightweight and durable whilst not having any reaction to the sulfuric acid inside the tank. The lid must also comply with the Manual Handling at Work Act. To achieve this, it will need to require less than 16kg of force per moving component, allowing it to be used by both male and female staff members individually (HSE, Simple manual handling risk filters,

1992). As shown in figure 1, the weight limit changes due to location. Seeing as the tank is 1020mm tall, it is acceptable to use the largest weight in this instance.

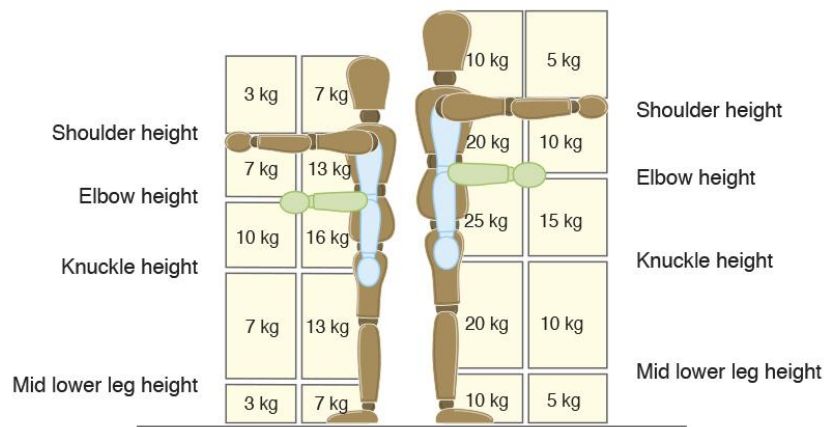


Figure 1 shows the limits for weight in relation to location and gender (HSE, Simple manual handling risk filters, 1992).

Designing the component to have minimal points where injuries can occur is essential; this includes avoiding sharp edges and crush zones. The tank is positioned in an industrial environment, and the users will already be wearing full PPE, including boots and gloves.

Time Plan

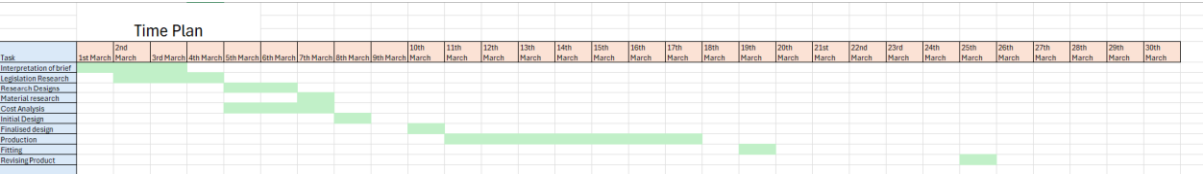


Figure 2 showcases a simplified timescale chart which shows the product completion taking 25 days.

Relevant Research

Cost

Key factors to include with cost are manufacturing costs, material costs, design costs, and installation costs. Retaining the 5mm thick stainless steel lid increases the production cost due to the use of precision fabrication tools such as a plasma cutter, CNC machines, lathes, and mills. The cost to outsource production will be shorter in the small numbers; however, the brief states that production will be in the low hundreds. The cost to have a square panel made following the same dimensions will be approximately £397 to produce, including material cost, labour, and running cost. According to Surefirecnc, the average time to cut a panel into the dimensions of the original is in the range of 230-250 seconds (McDonald, 2025).

Environment

The tank is set to be positioned alongside a production line, therefore, the tank will need to be sealed properly when not in use to prevent cross contamination. On the basis that the original lid is lifted fully off and taken to the side, it is apparent that there is excess space on at least one side of the tank. This area can be utilised in a few different designs that include an assisted removal of the lid and keeping it just to the side. Due to the 30% sulfuric acid contained within the tank, a material that can withstand permanent exposure to this whilst being kept at 25 degrees is essential.

Maintenance

The need to have to service a lid to a tank which has numbers in the hundreds should be avoided as much as possible. However, greasing of rollers and hinges is unavoidable, but the intervals between can be maximised as much as possible, minimising the risk of dust entering moving components will drastically reduce the need for servicing and will lower the possibility of a component failure.

Production

In order to keep production costs down, outsourcing multiple components is essential; thus, designing the lid in a way that integrates off the shelf components is beneficial to not only costs but time.

Material

When choosing a material for the task, there are many considerations. The most essential decision is picking one that can withstand constant exposure to sulfuric acids, followed by corrosion resistance, price, strength, weight, and ease of production. 8 key materials were compared on Granta to gain a visual analysis of the different properties (Granta, 2025). These 8 materials were selected based on the above reasoning, using the chart feature in Granta it is apparent that Inconel has the highest tensile strength but the second highest density, due to this the weight of the lid would most likely be over the 16kg limit, Inconel is also on the expensive side costing between £34 and £42 per Kg for the 625 grade. Tantalum-tungsten alloy has a good tensile strength however, it is also denser than stainless steel and costs £230-£330 per kg compared to the £5 to £8 of stainless steel. PTFE with 25% glass fibres had the greatest resistance against corrosion as well as being the most chemically resistant polymer among thermoplastics, and its unique nonstick property (Qiang Guo, 2022), on Granta, it is apparent that the tensile strength is not fully up to par; however, this can be improved by having PTFE coated stainless steel. another downside to PTFE is that it expands significantly with heat; however, under normal operating conditions of 25 degrees, this will not be an issue. Aluminium is a good all rounder when it comes to tensile strength vs cost and density, it will cost £2.27 to £3.18 per Kg. However, it will anodize and corrode dramatically with prolonged exposure. Coating it with a layer of PTFE will solve these issues.

The original design's total volume is 0.00903m^3 , calculated off the provided image in the design brief, assuming the 5mm thickness with a 15mm tall 5mm thick lip around the edge. Using the density provided on Granta, it can be calculated that this lid will weigh between 71.07 Kg to 75.13 Kg (Granta, 2025). Just swapping this material with aluminium will lower the weight down to between 24.3 kg and 24.65 Kg, then adding a 1mm thick coating of PTFE will increase the total volume up to 0.01269m^3 relating to a subsequent 0.00366m^3 of PTFE which will add an increased weight of 8.052Kg to 8.418Kg. this will bring the total weight of the original design with improved materials to 32.352Kg on the minimum to 33.068Kg on the high end. Using this information a simple design of a split lid with two hinges on either end is acceptable, this design is a simple yet effective choice due to it also weighing a total of 16.176Kg – 16.534Kg it will also fit within the Manual Handling at Work Act due to it weighing substantially less once supported on one end with a hinge (Granta, 2025) (HSE, Simple manual handling risk filters, 1992).

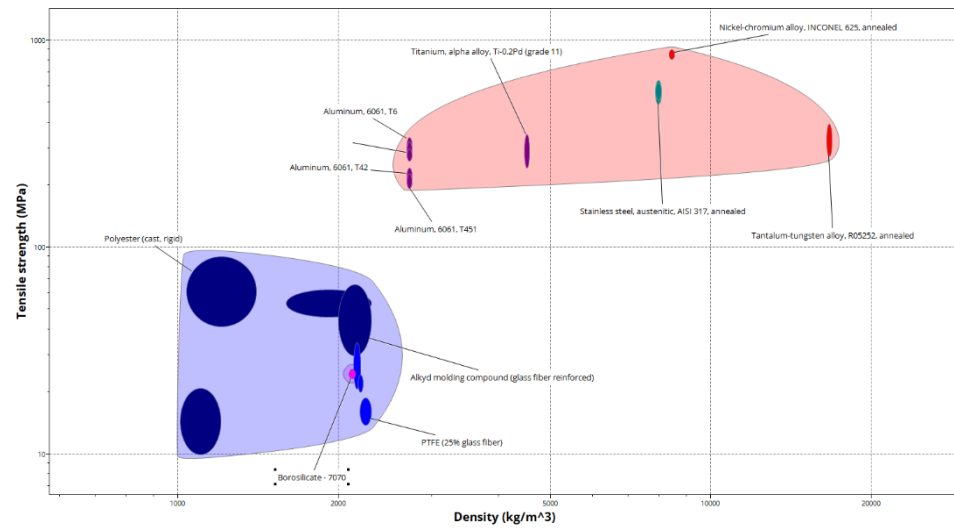


Figure 3 shows a range of different materials and their different qualities across tensile strength over density (Granta, 2025).

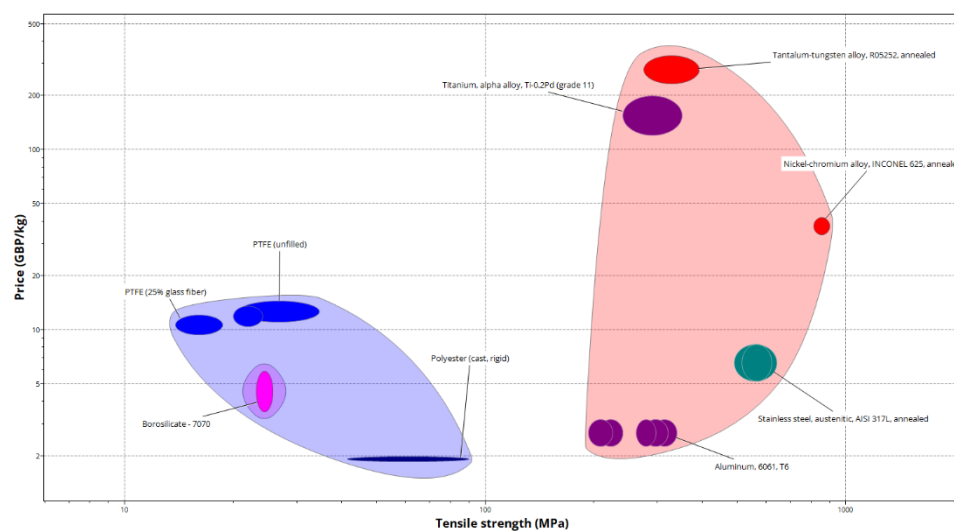


Figure 4 showcases the same materials but for tensile strength in relation to cost (Granta, 2025).

Design Sketches

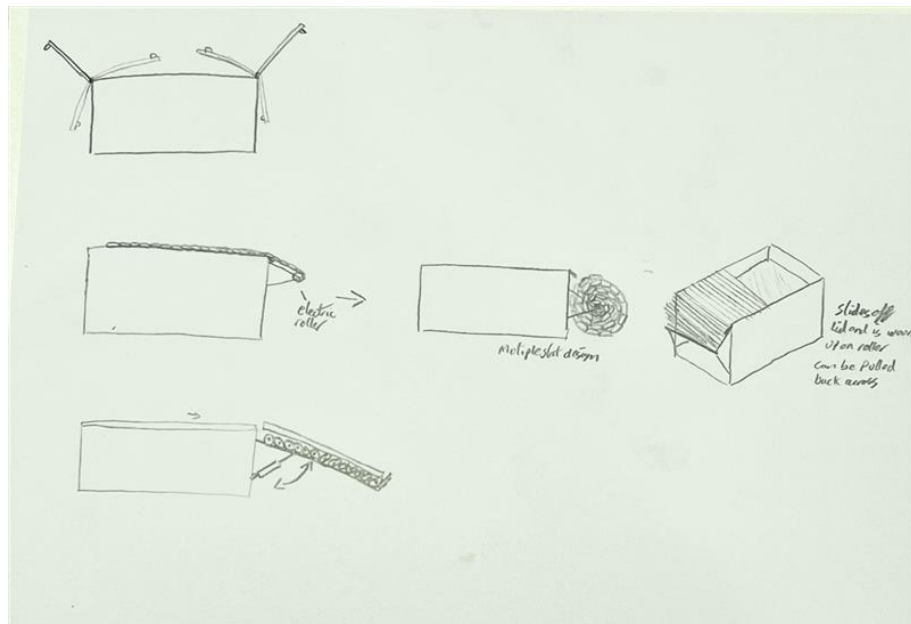


Figure 5 shows three original design sketches, none of which continued further due to reasons such as cost and maintenance.

The first design idea was to simply change the material type to something much lighter, as calculated above. simply having aluminium coated in PTFE will lower the weight to an acceptable amount, which will fit within all legislations. The positives of this design are that it is cheap and easy to manufacture; however, due to the material being thin, the risks of damage and complete failure are high. A central support beam will also be needed, and the removal of this before use is an unnecessary step.

The second design implemented a horizontal garage like door. This design had the greatest ease of use due to the electric mechanism requiring the push of a button and it only needing to be pulled back across when not in use. This design is more expensive than any other design present and is also the design that requires the most service due to the multiple moving parts.

The final initial design was having the lid made out of a lighter material and simply attaching a handle and sliding it off with the use of gravity and frictionless rollers. The implementation of an off shelf roller table in this example will dramatically cut down production time; however, with a table and at least 2 shocks being needed, it is also an expensive design.

Final Design

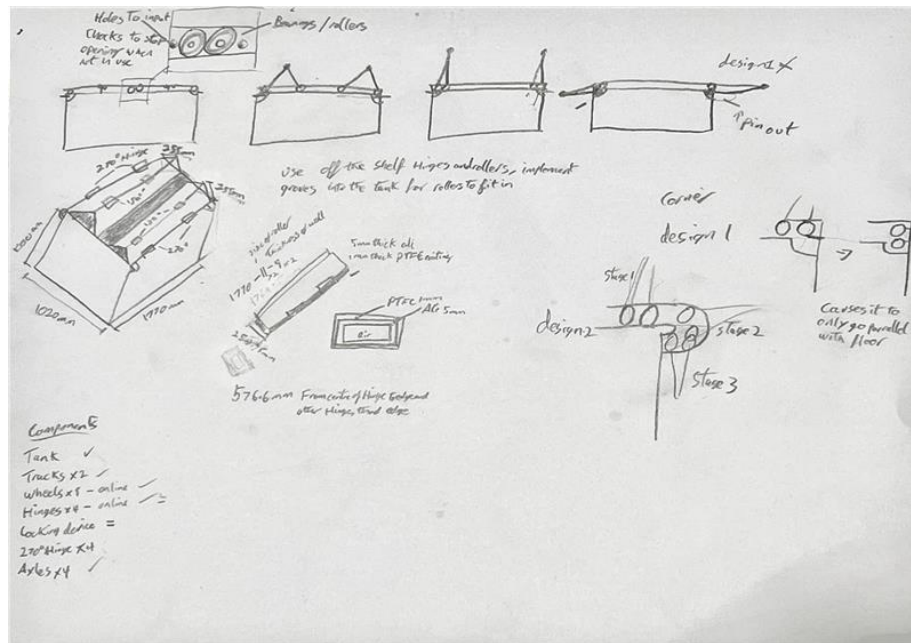


Figure 6 shows the two different stages of the final design as well as a check list of components

The initial design for this lid was taken from Kyle Hankinson, vice president of KCH Engineered Systems. The dual hinge was utilised to have the doors stand upright, as shown in stage three on figure 6. It was then further developed to have the lid be parallel with the top of the tank, utilising a drop-down area that will be blocked off with a pin when not in use. This design, however, took up unnecessary space around the tank. So, a second design was created, allowing the rollers to follow a curve and the outer roller to become the inner, thus flipping the orientation of the lid.

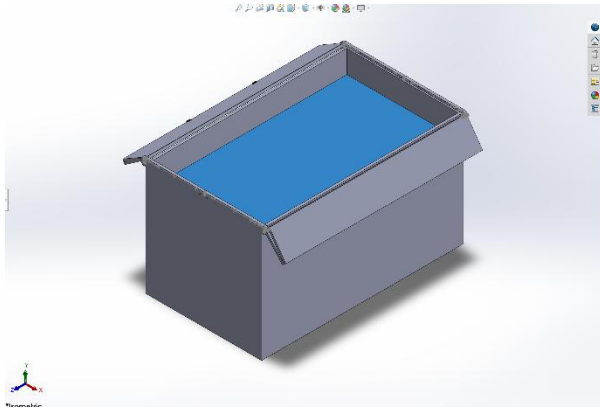


Figure 8 shows the tank with the lid open.

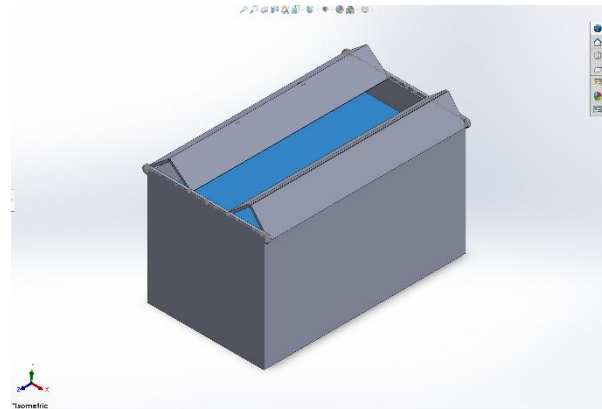


Figure 7 shows the tank with the lid part opened

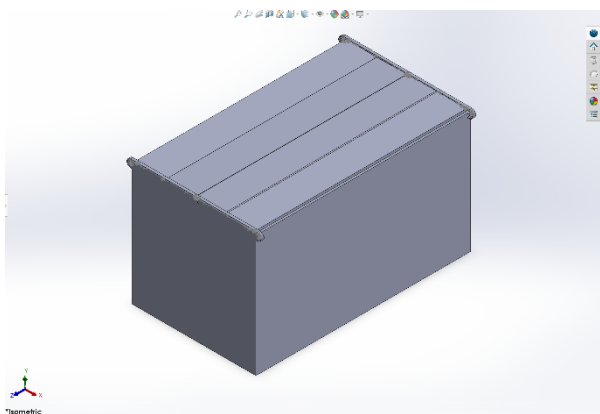


Figure 10 shows the lid fully closed.

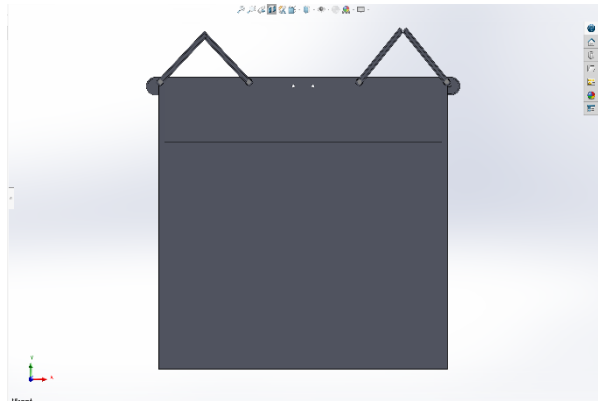


Figure 9 is a cross sectioned view of the roller mechanism.

The lid on this design is made up of 4 identical panels, each comprising a hollow box section of 5mm thick 6061 T6 aluminium with a further 1mm coating of PTFE on all 6 sides for further corrosion resistance. It is attached using two hinges, which were pre designed on solid works and can be outsourced to save on cost (BAYRAK, 2023). There was a solid axle going straight through the lids, attached at either end to a bearing wheel. like the hinges, these wheels will also be outsourced to cut costs (Thinhouy, 2021).



Figure 11 shows a close up of how the rollers make it round the arc to allow the lid to sit vertically down the side.

Technical Drawing

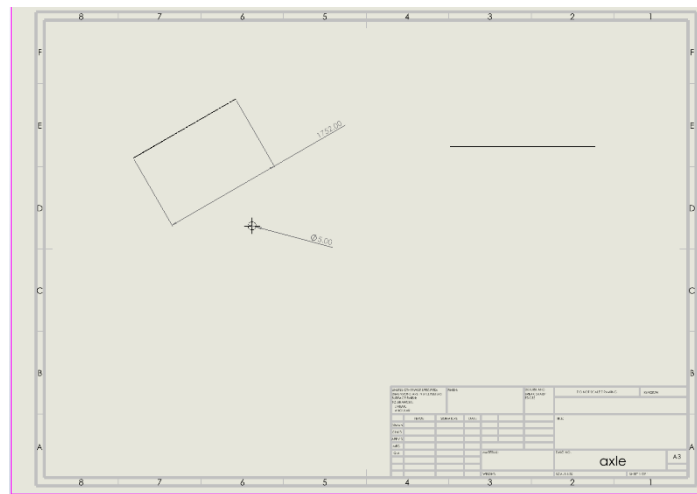


Figure 12 shows a technical drawing of the axle.

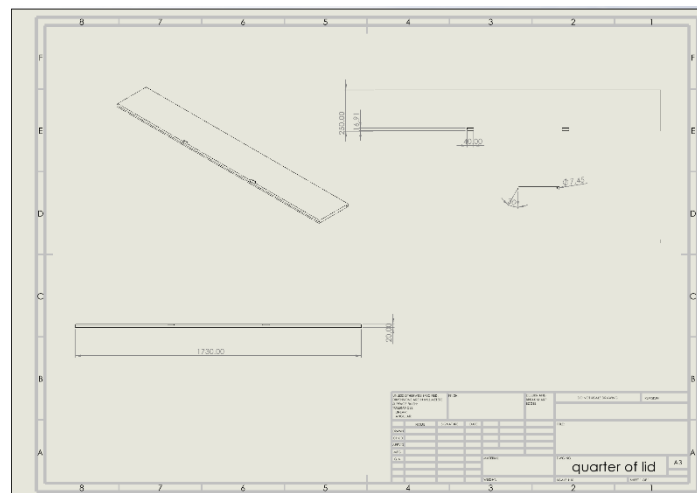


Figure 14 shows a technical drawing of the lid component.

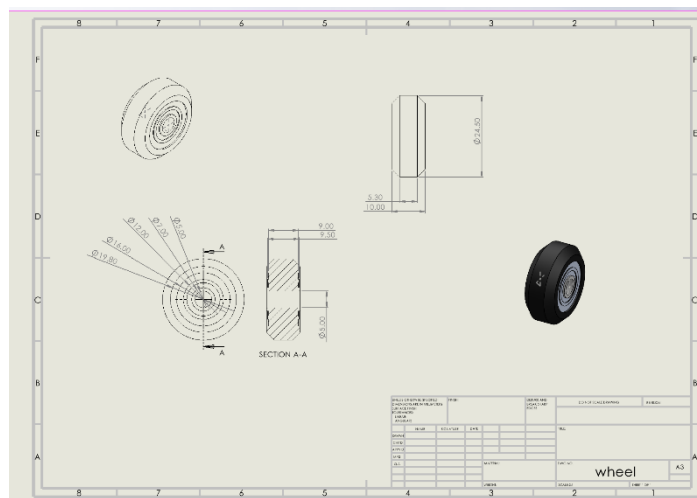


Figure 13 shows a technical drawing of the wheel (Thinhhouy, 2021).

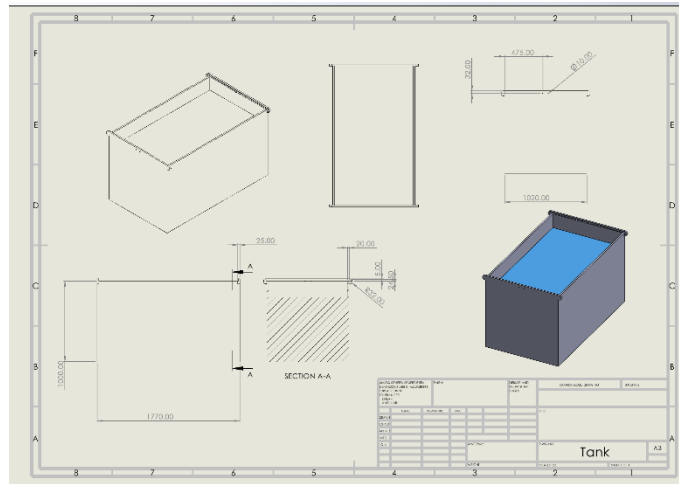


Figure 17 shows a technical drawing of the tank with new modifications.

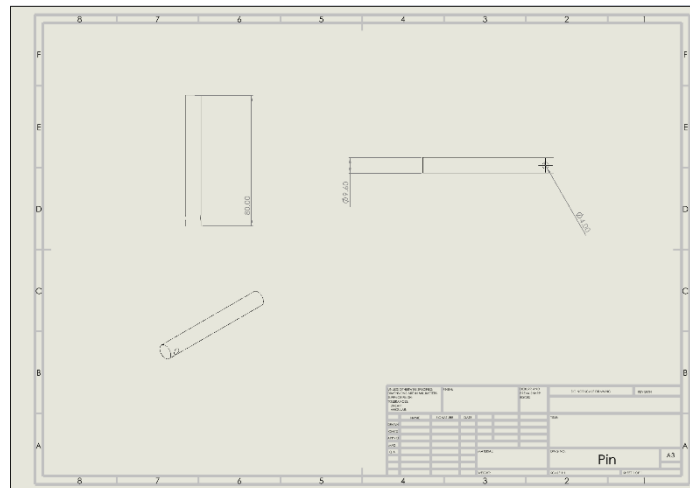


Figure 16 shows a technical drawing of the locking pin that can be attached to a keychain.

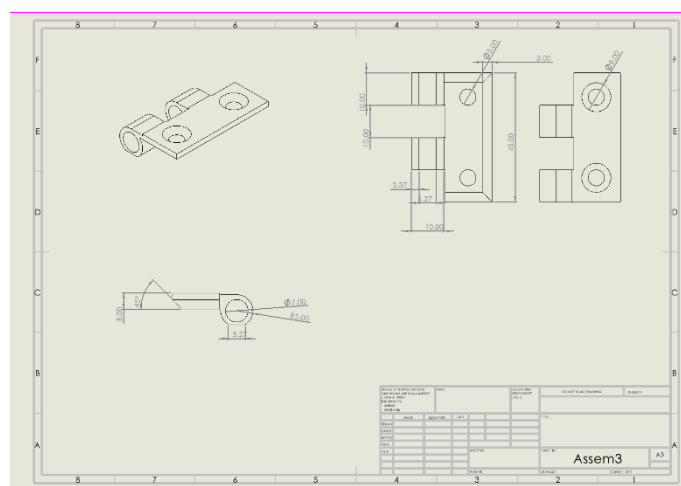


Figure 15 shows a technical drawing of the hinge taken from GrabCAD (BAYRAK, 2023).

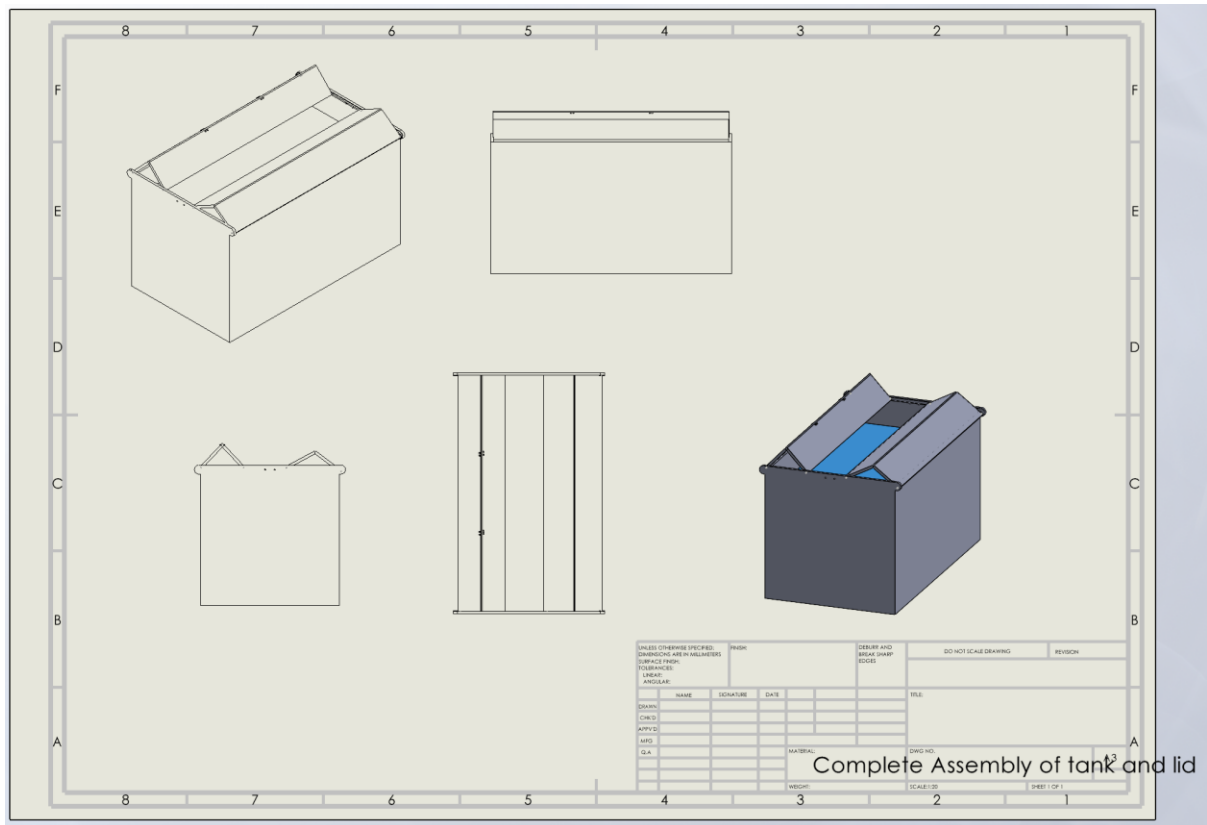


Figure 18 shows a technical drawing of the full complete assembly.

Manufacturing Processes

This design was chosen for the ease of production; the lid will first be created by getting some 5mm thick aluminium 6061 T6, and using a CNC machine will be cut to the 5 separate sheets to form the box section, it will then be welded up using a tig welder to form the box. Once the box has been created, it can then be fully coated in a 1mm thick layer of PTFE, this is done by either a spray or dip coating. Once the coating has fully sealed, the axle will then be placed into the box through the holes cut on the CNC.

The tracks will have to be made out of steel due to it being costly and difficult to mount aluminium to steel permanently. These can be cut on either a CNC machine or a plasma table and will be welded on top of the tanks.

Once the lids are attached to each other via hinges, the wheels can be attached and slotted into the tracks.

Justification

The final design was chosen due to its balance of usability, safety, manufacturability, and compliance with all legislations. By separating the lid into 4 lightweight panels of 6061 T6 aluminium with a 1mm PTFE coating, the weight of the design falls into the manual handling at work act threshold. This ensures that the lid can be operated by a single individual. This addresses the client's core concern about requiring one individual. The dual hinge and roller system not only removes any components above the tank for complete clearance but also minimises the risk of injury by eliminating many crush zones and sharp edges.

The use of off-the-shelf components like hinges and wheel bearings supports the client's goals of cost-effectiveness whilst simplifying manufacturing and future maintenance.

The combination of corrosion-resistant materials, minimal servicing needs and compliance with relevant safety legislation makes this design the most practical and suitable for a high use industrial environment.

Conclusion

This project set out to resolve a key usability and safety issue related to an existing adonisation tank lid, which required two operators and posed multiple health and safety issues.

The final lid design meets all critical requirements, including one person operation, reduced physical strain, full compliance with safety regulations such as COSHH and manual handling. Furthermore the use of modular parts and standard components makes the system cost effective to manufacture and maintain as well as being easily implemented across all tanks in all facilities.

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