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Engineering Problem

Engineering Design and Materials ACHA4001

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1 Introduction

This report documents the systematic engineering design process employed to address the problematic design of an anodization tank lid. The current lid is fabricated from 5 mm stainless steel with side handles that require a two-person lift, thereby posing significant health and safety challenges. In response to the client brief, a new hinged lid design was developed. This design incorporates a manual or automatic hinge mechanism along the top edge, allowing the lid to open upwards easily. It adheres to ergonomic principles and enables safe single-person operation while preserving the tank's structural integrity and original dimensions.

1.1 Interpretation of client brief

Summarize the problem:

The Lid of the Anodising tank is currently too heavy for a single person to lift so has a two person lifting requirement, this also poses as a potential health and safety risk. With the quantity specified (requiring production in the low Hundreds) there needs to be considerations of the manufacturing process.

Requirements for the new lid design are;

- Safe to operate
- Single-person operation
- Maintains tank material and dimensions
- Allows part clearance above the tank

2 Legislation considerations

The redesign of the anodization tank cover must comply with key health and safety regulations, including the Health and Safety at Work Act 1974, which mandates safe working practices, and the Manual Handling Operations Regulations 1992, requiring measures to reduce lifting risks. Additionally, the COSHH Regulations 2002 govern safe handling of hazardous substances like sulphuric acid. The design must also meet functional requirements: a weight limit of ≤ 10 kg to enable single-person operation, corrosion-resistant materials (e.g., stainless steel or reinforced polymers), and a cost target of $\leq £200$ per unit to align with production volumes. Compliance with BS EN ISO 12100:2010 (machinery safety standards) ensures structural integrity and user safety. These criteria ensure the solution is both legally compliant and operationally effective.

3 Part Specifications

The redesigned tank lid incorporates a hinged mechanism, operational manually or automatically, that facilitates smooth and controlled opening and closing. The design prioritizes ergonomic safety by significantly reducing the lifting effort required during operation. Material compatibility is ensured through the continued use of stainless steel, while the lid dimensions remain consistent with the existing tank specifications, at 510 mm in height and 1770 mm in length. The hinge design allows sufficient clearance above the tank, enabling the safe placement of anodised aluminium parts. Manufacturing feasibility is achieved by employing established processes such as laser cutting and CNC machining, suitable for low-volume production.

4 Time Frame

Project timeline with key milestones:

Phase	Activity	Duration
Research	Literature review, material studies	2 weeks
Concept Development	Sketching, preliminary designs	2 weeks
CAD Modelling	3D modelling and simulation	3 weeks
Technical Drawings	BS8888-compliant documentation	2 weeks
Prototyping	Manufacturing & assembly test	4 weeks
Evaluation	Testing and performance assessment	3 weeks
Final Report	Documentation & submission	2 weeks

Table 1 Timeline for prototype and production

5 Background

An extensive review of relevant literature informed the final design. Ergonomic studies underscore the importance of hinge-based mechanisms for reducing operator strain and enhancing safety (Chaffin, Andersson and Martin 2006). Several industrial case studies and reviews have highlighted the benefits of hinged lids over traditional manually lifted covers (Davis and Garner 2015). Furthermore, HSE guidelines stress that reducing manual handling risks enhances workplace safety and operational efficiency (HSE 1992). Additional research indicates that incorporating lightweight materials in hinge assemblies can markedly improve ease of use and durability (Wilson and Giles 2017). These findings collectively validate the selection of a hinged lid mechanism as the optimal solution for this design challenge.

During the concept development phase, three primary design options were considered:

1. **Sliding Lid System:** Working in a similar effect to a drawer, two halves sit on ball bearing rails. This design also incorporates two handles to assist in ease of use, this design is effective and in theory fairly reliable with the rails being made from hardened steel. A major disadvantage is that it require 0.5m either side for the lid to be opened fully, and could cause a health and safety risk.

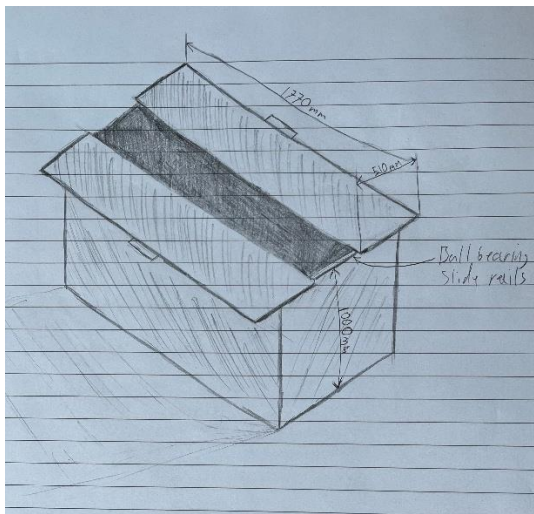


Figure 1 Design 1, sliding lid

2. **PTFE Balls:** Using PTFE balls in anodising baths is seen fairly commonly. They provide a cover over the top of the anodising tank and insulate to keep heat in reducing energy costs. Another advantage is that they can be left in place while parts are lowered in and out of the tank. Disadvantages: they do not supply any protection against people putting their hands in or leaning on the tank creating a health and safety risk, as well as the risk of foreign objects entering the tank as there are larger gaps between the balls and lack of rigidity.

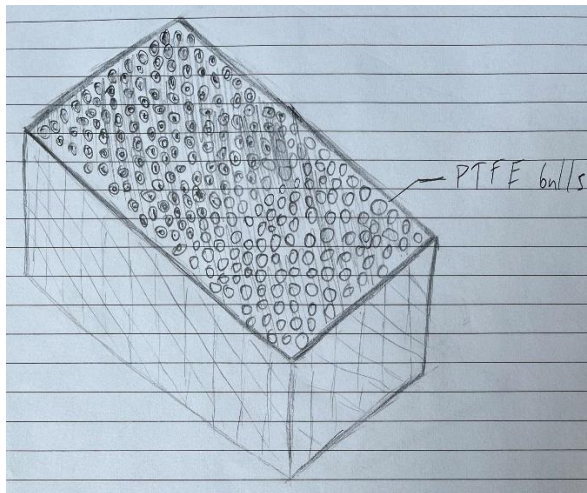


Figure 2 design 2, PTFE balls

3. **Hinged Lid Mechanism:** Featuring a simple hinge along the either edge of the tank for upward opening. This concept provided superior performance, minimized manual handling risks, and simplified retrofitting on existing tanks.

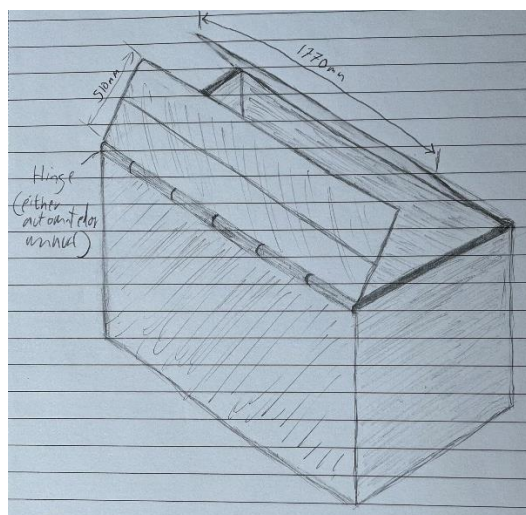


Figure 3 design 3 hinged lid

6 Final Design

The final design is a hinged lid mechanism featuring a robust stainless steel construction complemented by lightweight alloy components in the hinge assembly. This system allows for smooth, controlled upward opening, thereby facilitating single-person operation and significantly reducing the risk of manual handling injuries (Chaffin, Andersson and Martin 2006). It is easily retrofitted to existing tank structures while maintaining the required dimensional and operational clearances. The simplicity of the hinge system ensures cost-effectiveness and scalability across various company sites, making it a practical solution for addressing both safety and production needs (Davis and Garner 2015; Wilson and Giles 2017). The lid itself will be constructed out stainless steel as it is cost effective as it is so accessible and there is a lot of existing infrastructure making manufacturing the parts very easy.

The model includes comprehensive views that display the lid, hinge placement, and operational clearances. All technical drawings were produced in accordance with BS8888 standards (BSI 2021) and incorporate precise dimensions. These documents serve as essential guides for manufacturing and maintenance, ensuring that the assembly meets rigorous industrial and regulatory standards.

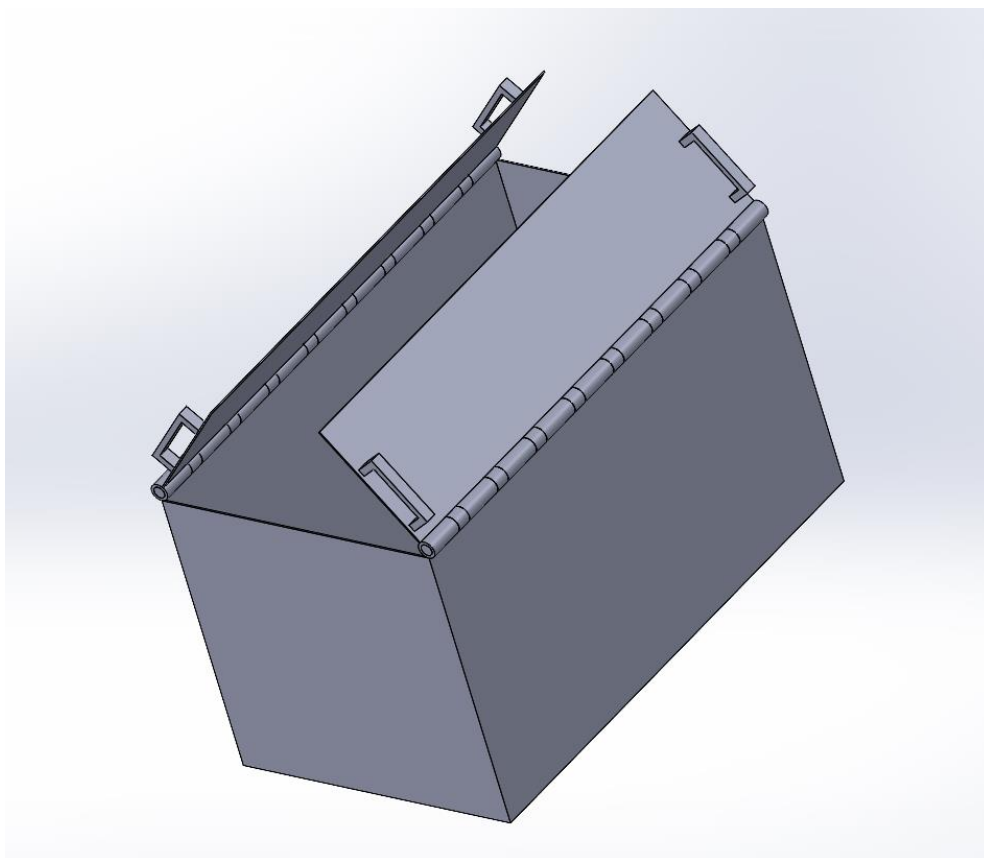


Figure 4 Final design CAD model

7 Manufacturing Processes

Various manufacturing processes may be utilised in constructing the anodization tank lid, each offering unique advantages and cost implications. Laser cutting is widely employed for stainless steel due to its high precision and ability to produce complex geometries with minimal thermal distortion. According to Krrass (2023) and GF Laser (2023), laser cutting costs typically range from approximately £50 to £100 per operational hour, with factors such as material thickness and assist gas usage notably influencing the final price. Alternatively, CNC machining delivers excellent dimensional control, particularly crucial for intricate components like hinge assemblies. In the UK, CNC machining rates generally fall between £30 and £50 per hour, as noted by Get It Made (2024), making this method attractive for projects that require high repeatability and tight tolerances.

For high-volume production, stamping and deep drawing offer significant cost benefits through economies of scale, despite having higher initial tooling expenses that can run into several thousand pounds. These processes are advantageous for producing flat or simple curved parts at a lower per-unit cost when large batches are feasible (Be-cu 2023; Wedge Products 2023). Welding, employing processes such as TIG or MIG, is indispensable for joining major components securely. Checkatrade (2023) estimates welding costs to be around £50 per hour, though actual prices will depend on job complexity and operator skill.

Mechanical fastening using bolts, screws or rivets represents a modest cost option, with material costs estimated at roughly £25 per square metre (Vehicle Body Building Solutions 2024). Such fasteners also offer the benefit of easy disassembly for maintenance. Surface finishing processes—like passivation and polishing—are essential for enhancing corrosion resistance and overall aesthetics, but may increase production costs by an additional 20–40% (Keller Technology 2023). Finally, additive manufacturing can be employed for rapid prototyping or low-volume production; however, its higher per-unit cost is largely attributable to significant initial equipment investments (Thomas and Gilbert 2014).

8 Conclusion

The redesigned anodization tank lid (featuring a hinged mechanism) provides significant improvements in safety, usability, and operational efficiency. By enabling single-person operation, this design reduces the risk of manual handling injuries while maintaining the required functional specifications and compatibility with existing tank systems. Preliminary CAD and technical documentation confirm that the proposed solution is feasible for low-volume production. Future work will focus on prototyping, field testing, and further refining the automation aspects of the hinge mechanism. Additional considerations include sensor integration for performance monitoring and predictive maintenance to further enhance safety and efficiency.

9 References

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