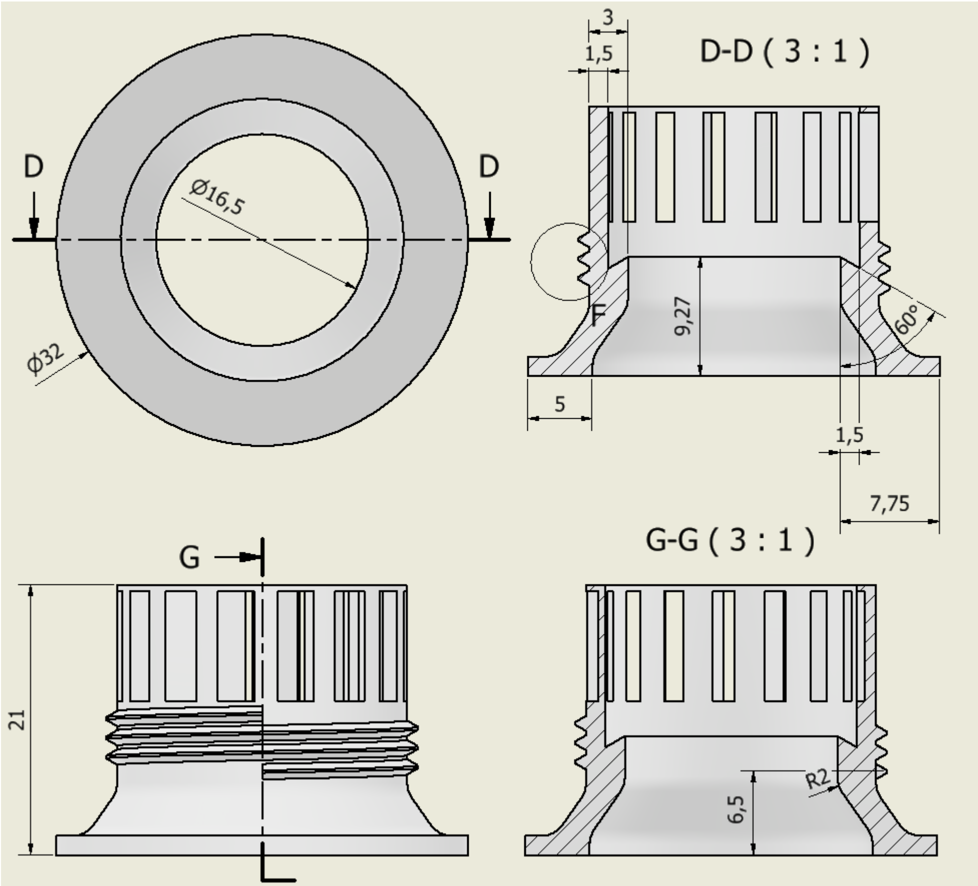
2025

Design Portfolio



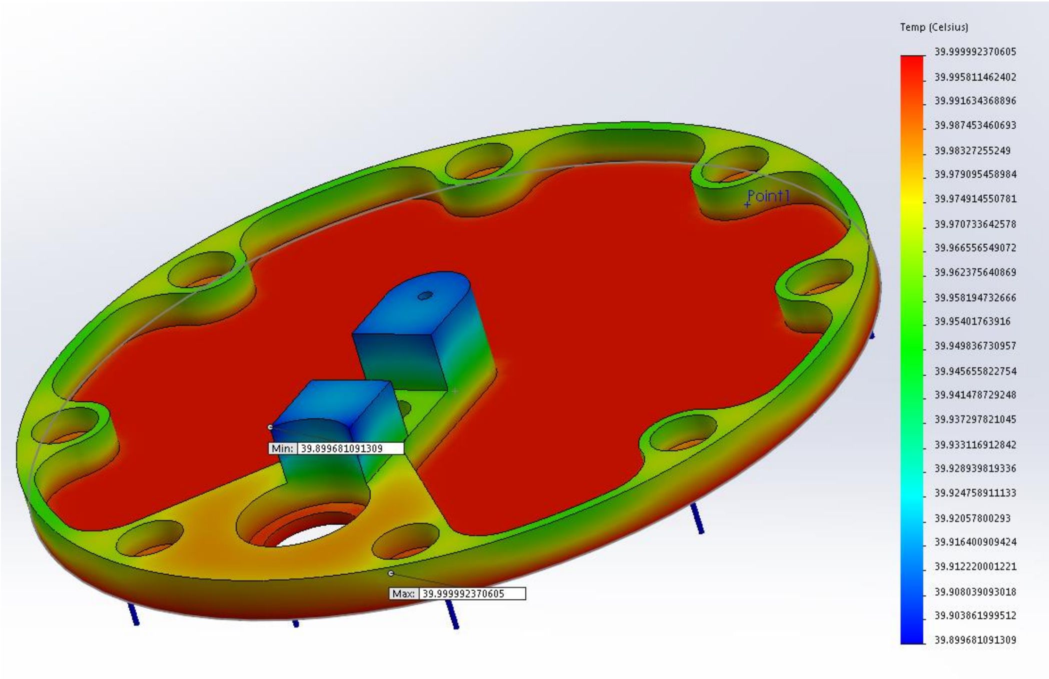
Oscar Dubois

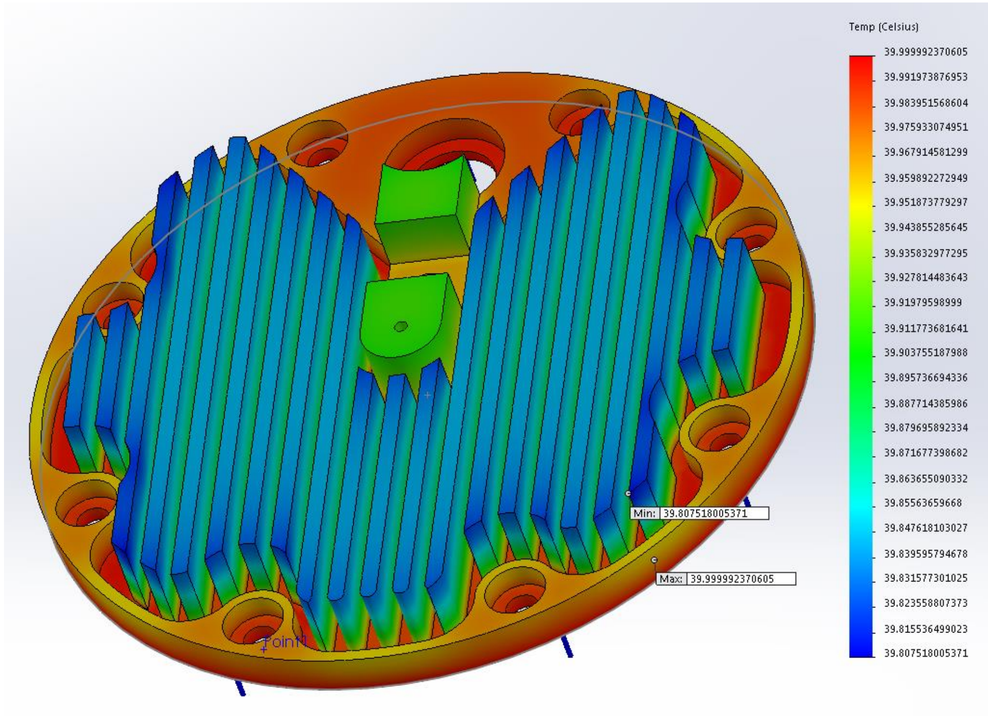
2/24/2025

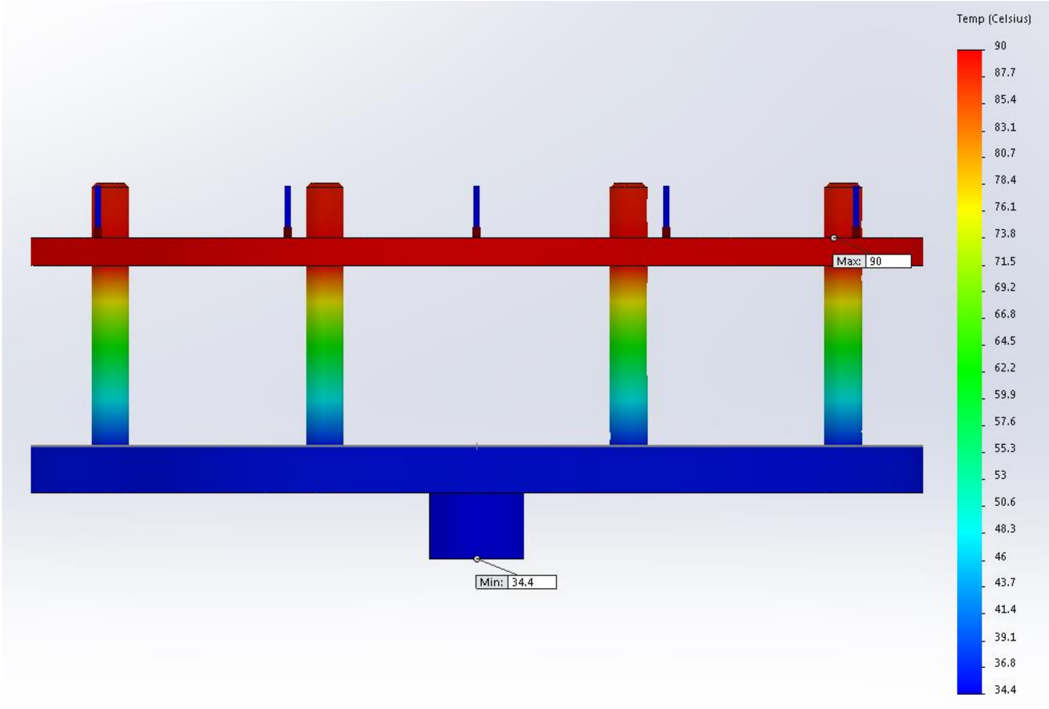
Contents

Stirling Engine

Thermal Optimization of Top Plate and Fastener Material



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87.7
85.4
83.1
80.7
78.4
76.1
73.8
71.5
69.2
66.8
64.5
62.2
59.9
57.6
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50.6
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43.7
41.4
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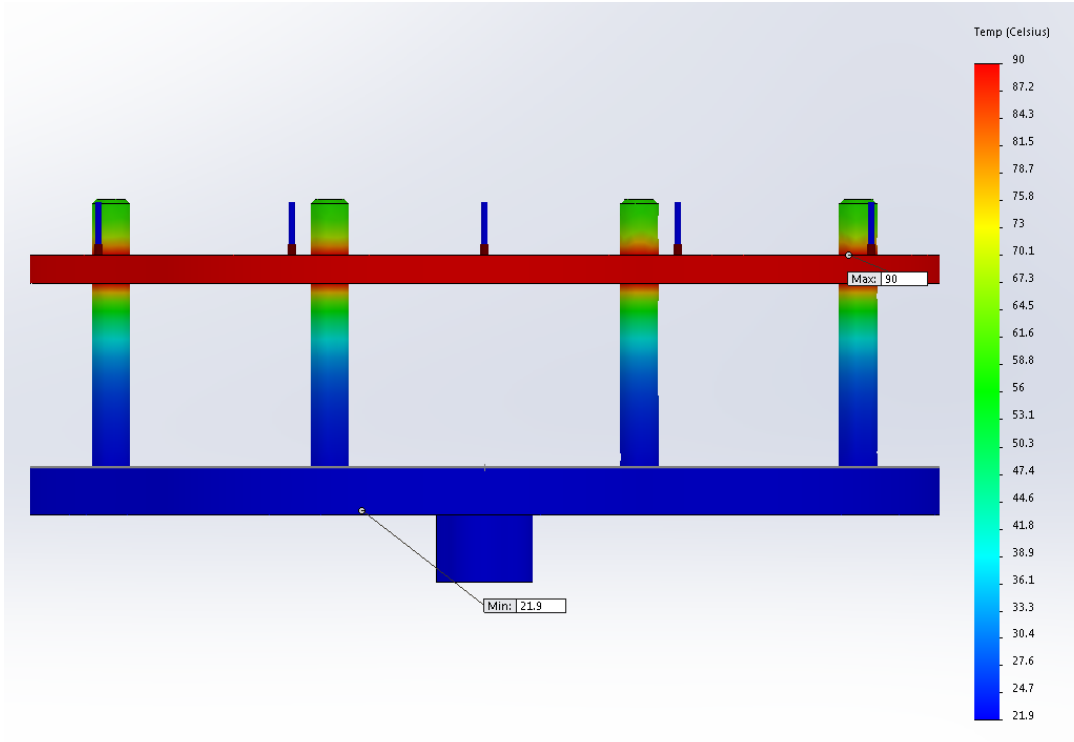
36.8
34.4
Max: 90
Min: 34.4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53.1
50.3
47.4
44.6
41.8
38.9
36.1
33.3
30.4
27.6
24.7
21.9
Max: 90
Min: 21.9

Project Role: Design Engineer / Thermal Analyst

Project Goal: To optimize the thermal performance of a Low-Temperature Differential (LTD) Stirling engine by addressing two key areas: 1) enhancing heat dissipation from the top (cold) plate through heat sink redesign, and 2) minimizing heat transfer between the hot and cold plates by selecting an appropriate fastener material.

Background:

LTD Stirling engines operate on small temperature differentials, often as low as 3°C. This project's application involved utilizing the heat from a mug of hot water (approximately 90°C) as the heat source. Maximizing the temperature difference between the hot and cold plates is crucial for efficient engine operation. This required both effective cooling of the cold plate and minimizing thermal bridging between the plates.

1. Top Plate Heat Sink Redesign:

Design Modifications:

The original top plate design was modified to incorporate a finned heat sink to increase surface area and promote convective heat transfer. Key design considerations included:

- **Fin Alignment:** Parallel fins were chosen for simplified manufacturing.
- **Manufacturability:** Fin spacing and offset from the plate perimeter allowed for efficient material removal using standard milling operations. The "offset" design enabled single-plane machining, reducing complexity. A single cutting tool size could be used, streamlining the process.
- This allowed the design to be manufactured with a standard milling machine.

Thermal Analysis (Heat Sink):

A steady-state thermal analysis was conducted using [Specify Software, e.g., ANSYS, SolidWorks Simulation]. Boundary conditions included:

- **Bottom Surface Temperature:** 40°C constant temperature.

- **Convection Coefficient:** 25 W/m^2K (natural convection).
- **Ambient Temperature:** 22°C.
- **Radiation:** Low emissivity (0.05) and a conservative view factor of 0.5 were used. Radiative heat transfer was deemed negligible, justifying the lack of fin tapering.

Results (Heat Sink):

The redesigned heat sink showed a modest improvement. The original design had a maximum temperature of 39.99999237°C, while the redesigned plate had a minimum of 39.80751801°C, a difference of 0.19247436°C. While measurable, this indicated further optimization might be needed.

2. Fastener Material Selection (Nylon vs. Steel Bolts):

Thermal Analysis (Fasteners):

A separate steady-state thermal analysis compared the impact of steel and nylon bolts. Boundary conditions were:

- **Bottom Plate Temperature:** 90°C (simulating hot water contact, with some assumed heat loss).
- **Ambient Temperature:** 22°C.
- **Convection Coefficient:** 25 W/m^2K (natural convection).
- **Radiation:** 0.05 emissivity for metallic components; negligible for nylon.
- **Simplifications:** Internal components between plates were neglected to focus on bolt material influence.

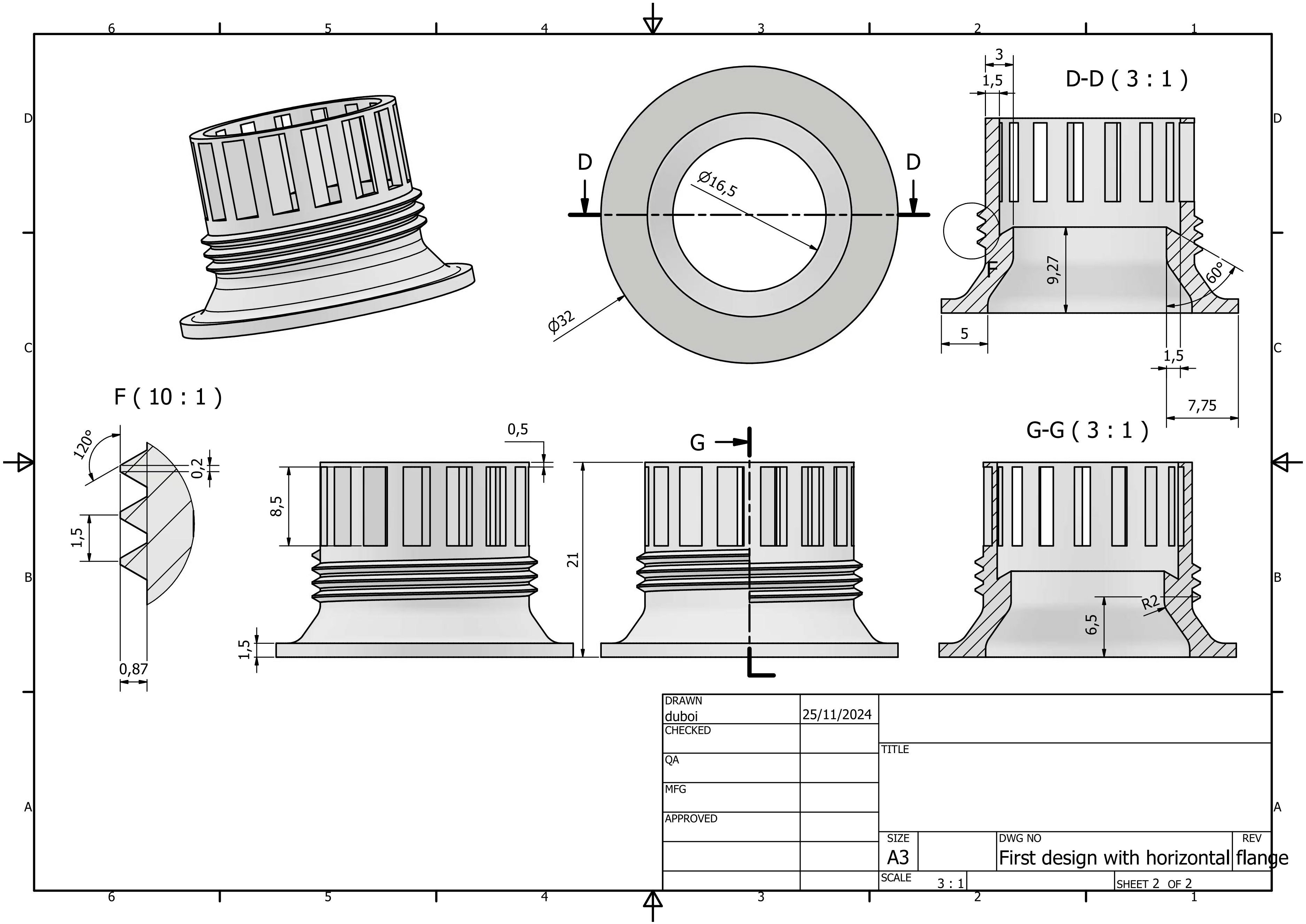
Results (Fasteners):

- **Steel Bolts:** System temperature range: 90°C to 34.4°C. Steel acted as a thermal conductor, reducing the temperature differential.
- **Nylon Bolts:** System temperature range: 90°C to 21.9°C. Nylon's low thermal conductivity significantly reduced heat transfer, maximizing the temperature difference.

Overall Conclusion:

The project addressed two critical thermal aspects of the LTD Stirling engine design. The redesigned finned heat sink on the top plate provided a small improvement in heat dissipation, while the selection of nylon bolts over steel bolts dramatically improved the engine's thermal performance by minimizing heat leakage between the hot and cold plates. The nylon bolts, acting as thermal insulators, were crucial for maintaining the necessary temperature differential for efficient engine operation. The combination of these design choices contributes to a greater power output and improved overall performance of the LTD Stirling Engine. Further optimization of the heat sink, potentially through increased fin density or alternative materials, could be considered for future iterations.

Waterproof Nozzle



Waterproof Cable Gland (IPX7/IPX8) for Submersible Enclosures

Project Role: Consultant Mechanical Design and CAD Engineer

Project Goal: Developed a robust, reusable cable gland achieving IPX7 and IPX8 waterproof ratings for integration with TPU enclosures. Target applications included VHF radios, microphones, and insulin pumps, requiring reliable submersion protection.

Design Description:

The three-component system comprised:

1. **TPU Base:** Injection-molded with a 5mm wide, 1.5mm thick flange for HF/RF welding directly onto the enclosure's exterior. This improved upon a previous seam-welded prototype, enhancing manufacturing efficiency and robustness. A modified buttress thread was designed for easy mold release.
2. **TPU Cap:** Injection-molded, engaging with the base's threading to compress the internal seal.
3. **Silicone Sealing Bung:** Precision-molded, providing the primary waterproof seal. A central aperture accommodated cables from 2.5mm to 5mm. Different bung sizes were achievable from a single tool. Nominal dimensions were 19mm diameter and 10mm length.

Manufacturing Process:

- **Prototyping:** Initial prototypes and low-volume runs (up to 1500 units) utilised a Manumold process for rapid iteration and validation.
- **Production Tooling:** A plan existed for a hardened steel injection mold for mass production after successful testing and market validation.

Key Design Innovations:

- **Flange-Based Welding:** Improved integration and structural integrity compared to seam welding.

- **Optimized Thread Design:** Enabled easy part removal from the mold.
- **Modular Bung System:** Accommodated various cable diameters, increasing versatility.
- **Material Selection:** Facilitated HF/RF welding to existing products.

Relevant Context:

The design leveraged prior experience with IPX6-rated enclosures (e.g., Aquapac Radio Mic Cases 158A, 548) and existing TPU integration techniques (e.g., Aquapac Waterproof Camera Case 428, Carmo TPU inflator valves), specifically the flange-welding approach. The gland represented a significant waterproofing performance upgrade. Cable gland reusability exceeded the ten uses. The team also investigated utilising a harder, more durable plastic for the two main parts.

Airbag for prevention of collarbone fracture

Design of a Clavicle Protection System for Cyclists

Introduction

This project focuses on the development of a device to prevent clavicle fractures in cyclists. Clavicle injuries are common in cycling, particularly among experienced riders who train for more than ten hours per week. The "Hovding helmet" serves as inspiration, demonstrating the feasibility of sensor-activated airbags for impact protection.

Challenges

The unpredictable nature of cycling falls presents significant challenges. Modeling kinematics requires assumptions about rider trajectory and impact conditions. Additionally, the chosen design must balance functionality, durability, ventilation, and mass.

Methodology

The design process followed a structured framework:

1. **Client Need:** Identify the target market and their needs.
2. **Objectives:** Define specific design goals.
3. **Pugh's Total Design:** Utilize a design matrix to evaluate and compare multiple concepts.
4. **Sequential Analysis of Functional Elements (SAFE):** Analyze functional elements sequentially to refine the design.
5. **Movement and Forces:** Analyze the kinematics of a fall to predict impact forces.
6. **Reference Product:** Analyze existing products for inspiration and benchmarking.

Concepts

Several concepts were explored, including:

- Adapting existing bicycle helmet technology.

- Implementing a garment with integrated protection.
- Borrowing designs from other sports, such as American football and motorcycling.

Design and Analysis

The final design consists of an airbag system activated by accelerometers and gyroscopes. This system is integrated into a garment worn by the cyclist.

Kinematics were analyzed using Solidworks and ADAMS software. A 1 DOF model was created, incorporating anthropometric data and British standards. The model was validated using Hertzian contact theory, static friction models, and Lagrangian substitution.

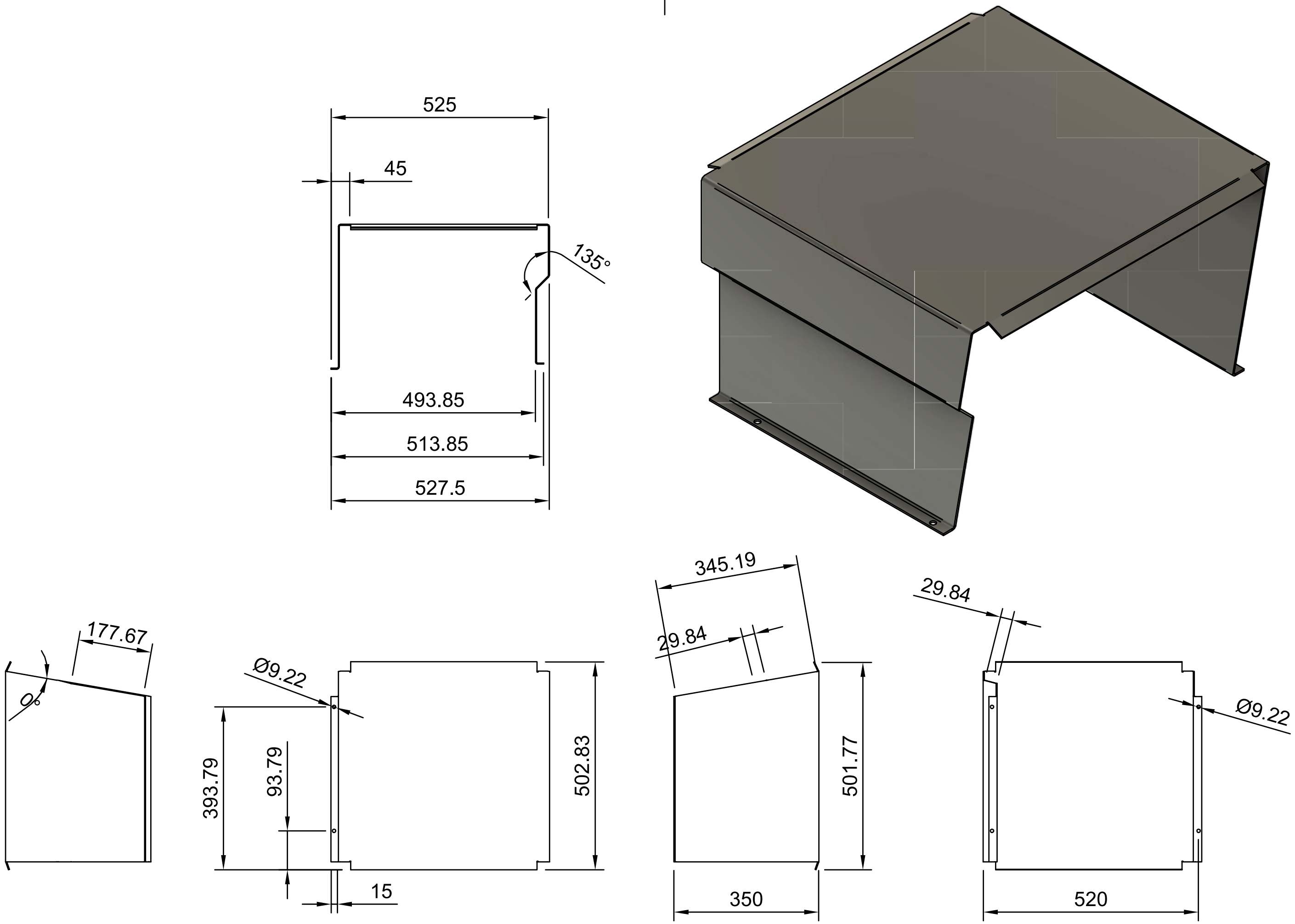
Results and Conclusion

The chosen design has the potential to reduce peak impact forces on the clavicle. However, further refinement is necessary, including:

- Finite element analysis (FEA) of the clavicular system.
- Development of a slip plane mechanism to further dissipate impact energy.
- Rigorous testing to validate the design's effectiveness.

This project demonstrates the application of engineering principles to address a real-world safety concern. The design process involved a combination of research, analysis, and simulation to develop a viable solution. Further development and testing are necessary to bring this design to market

Gearbox Cover



Dept.	Technical reference	Created by	Approved by
		Oscar Dubois 28/11/2024	
		Document type	Document status
		Title: Gearbox shroud	DWG No.
			Rev. / Date of issue / Sheet 1/2

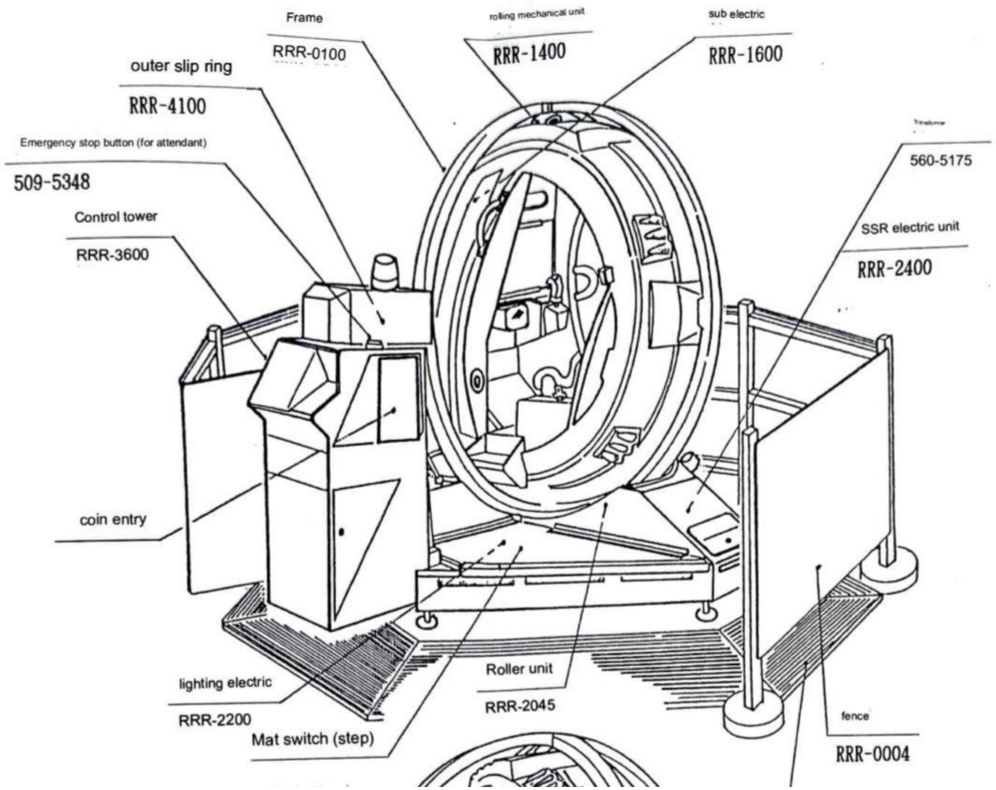
Sega R360 Motor and Gearbox Cover

The Sega R360 is an advanced motion simulator arcade game that uses a gyroscope to rotate players 360 degrees.

The gearbox cover is a critical component that protects the complex gear system that drives the gyroscope. The design of the gearbox cover prioritises safety, accessibility, and durability.

The gearbox cover on the Sega R360 was designed to mitigate potential mechanical and electrical hazards.

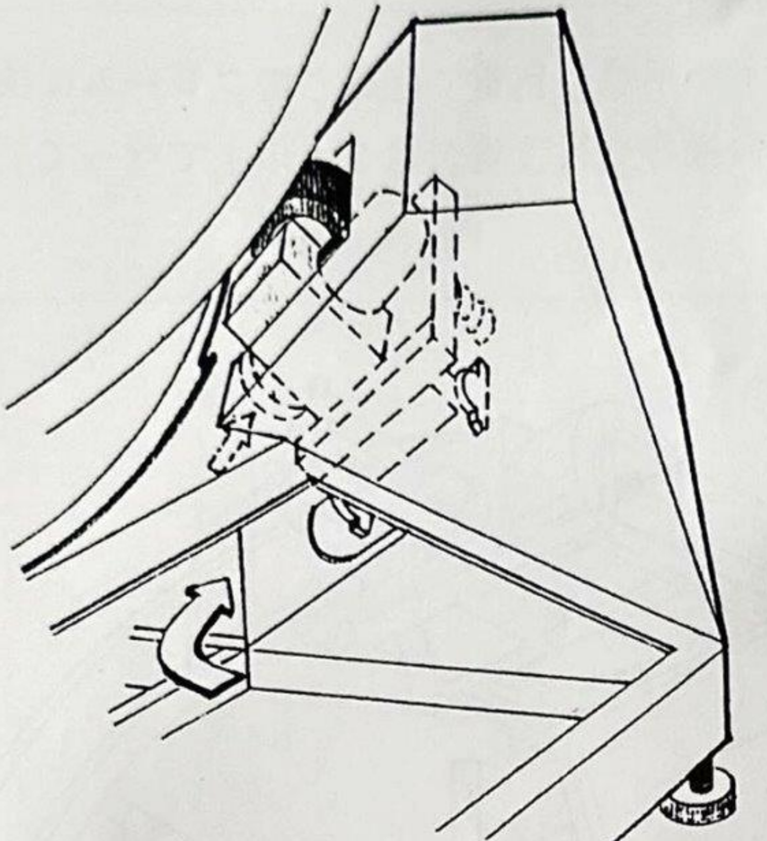
A damaged or improperly secured cover could have led to mechanical failure, potentially causing injury. Additionally, if the cover was not properly insulated, it could have led to electrical failure, pote ntially causing a fire or electric shock.

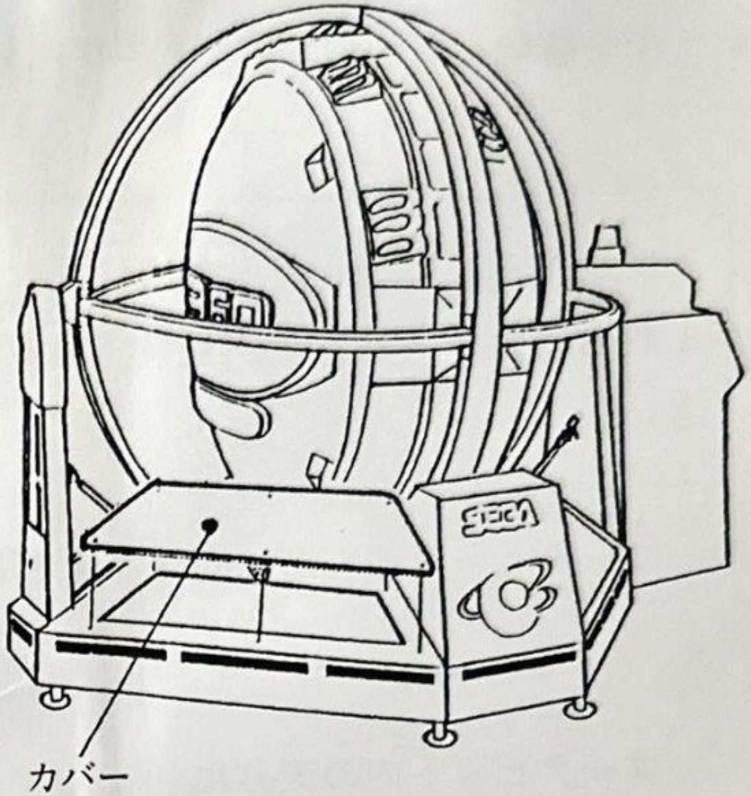


2．コックピットを縦に回転させる場合

ベースの右図の位置のカバーを外します。

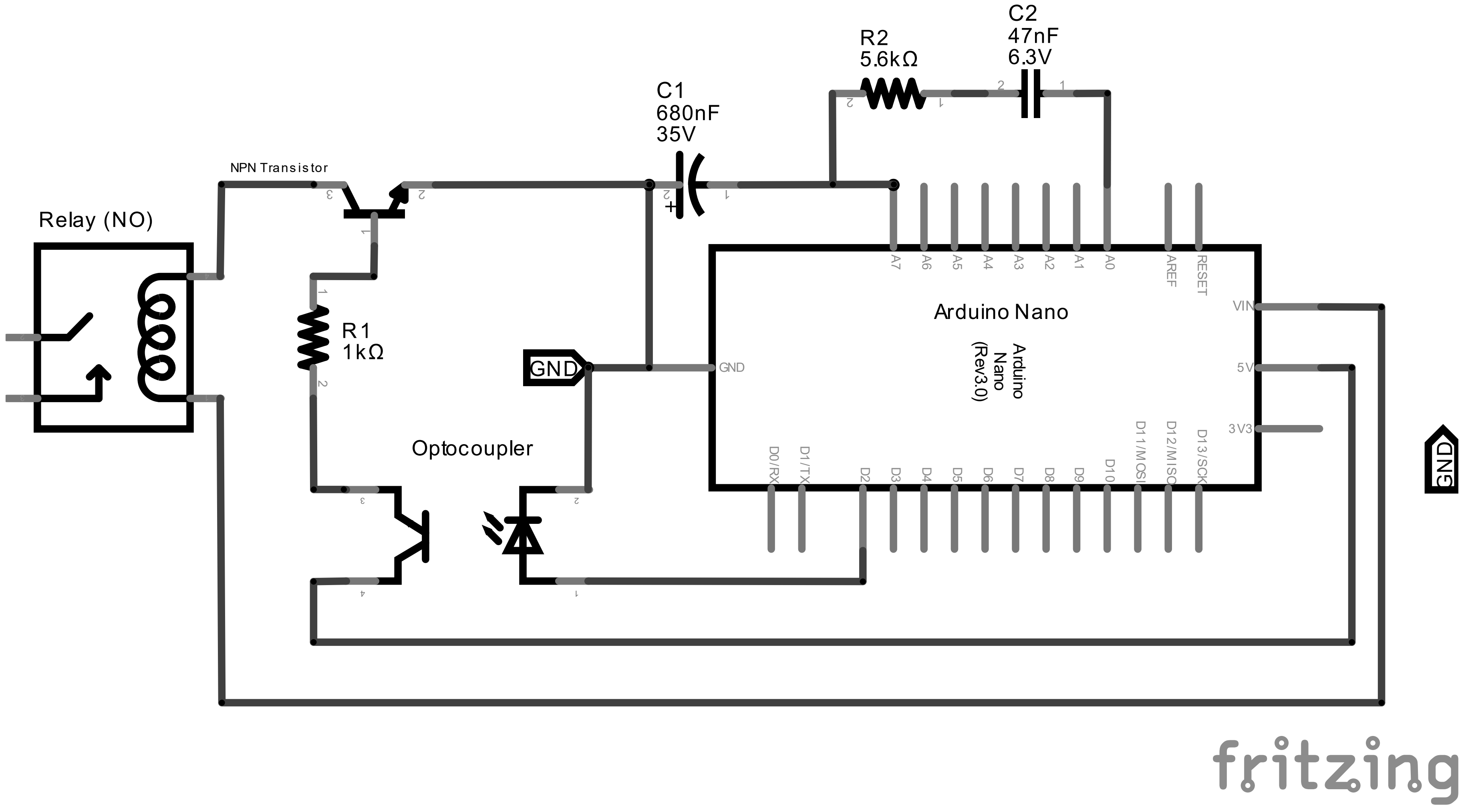
（M５ネジ６本）

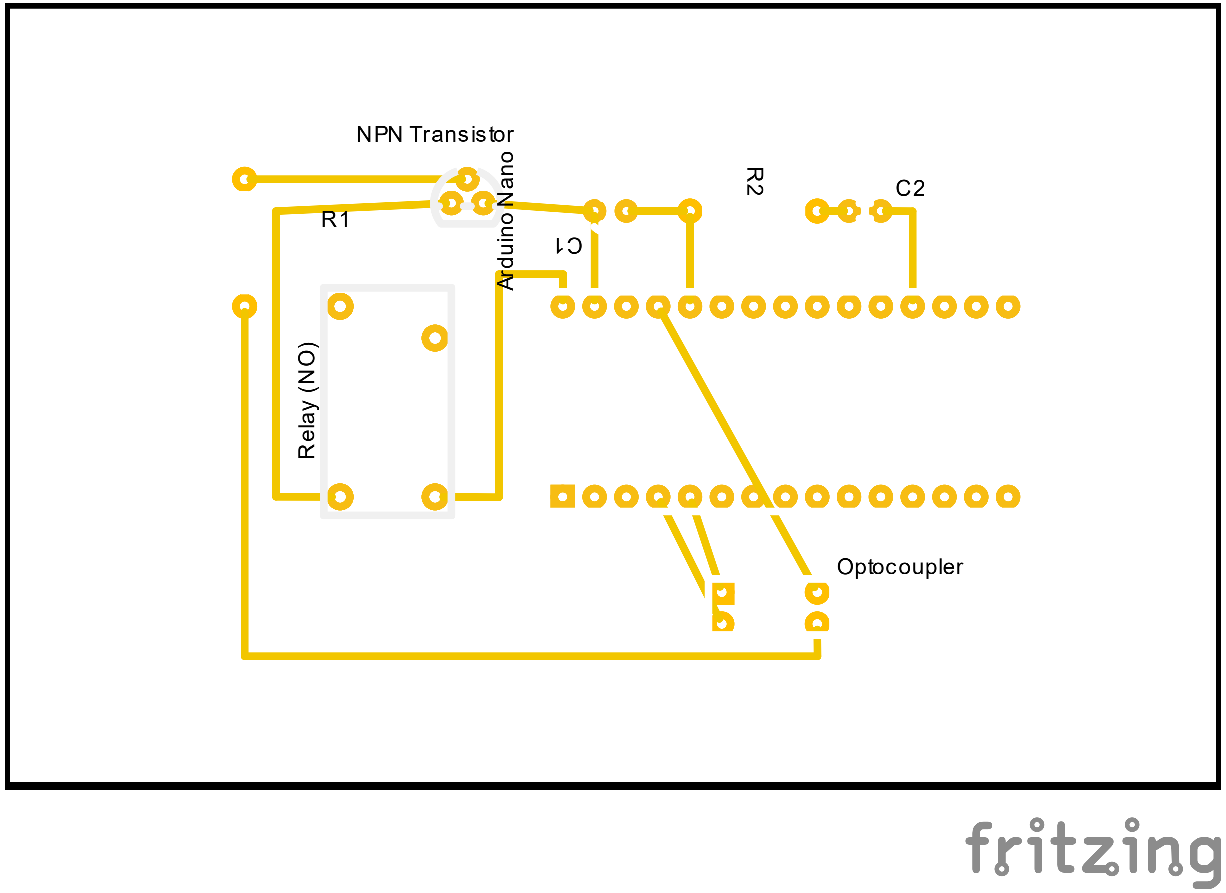




コックピットが不意に動き出さないように外側のフレームを二人で支

Optical Switch (electronic design)

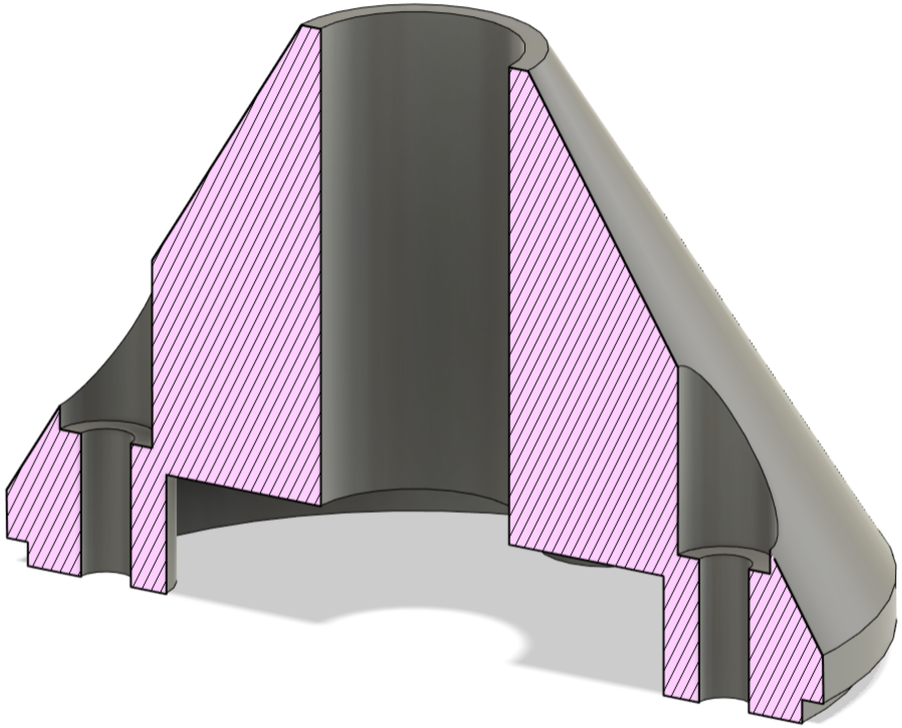


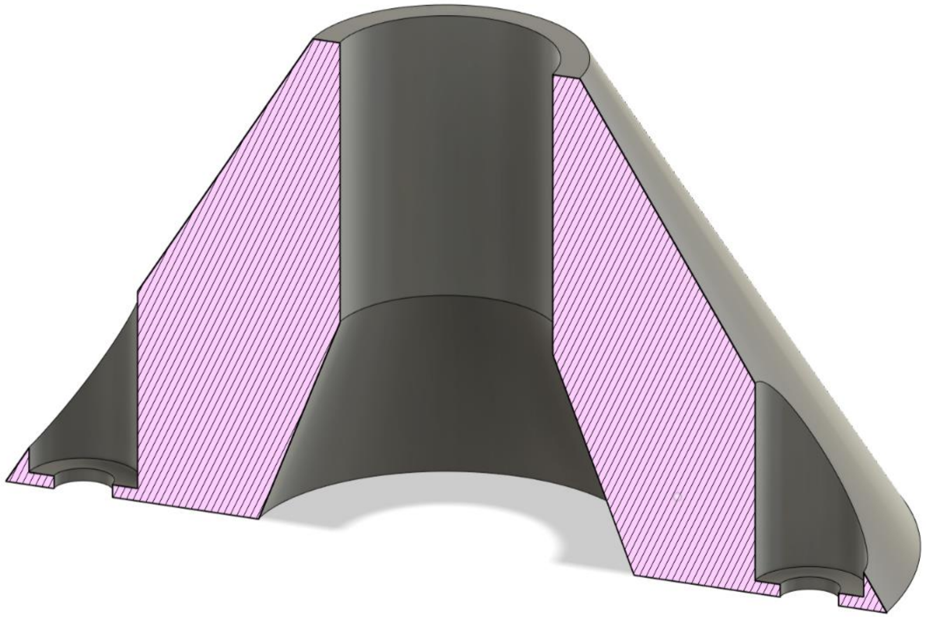


More complex schematics needed...

Replacement Motor Housing

Refabrication of a Linear Motor Nozzle for Vestibular Experiments





Project Overview

This project involved the restoration of a linear motor used in vestibular experiments. The motor had seized due to age, requiring the refabrication of its nozzle. The complexity of the nozzle's geometry presented challenges for traditional manufacturing methods.

Challenges

The nozzle's design included overhanging features that are difficult to produce using conventional 3D printing techniques. These features typically require extensive support structures, which can be time-consuming to remove and may compromise the final part's accuracy.

Solution

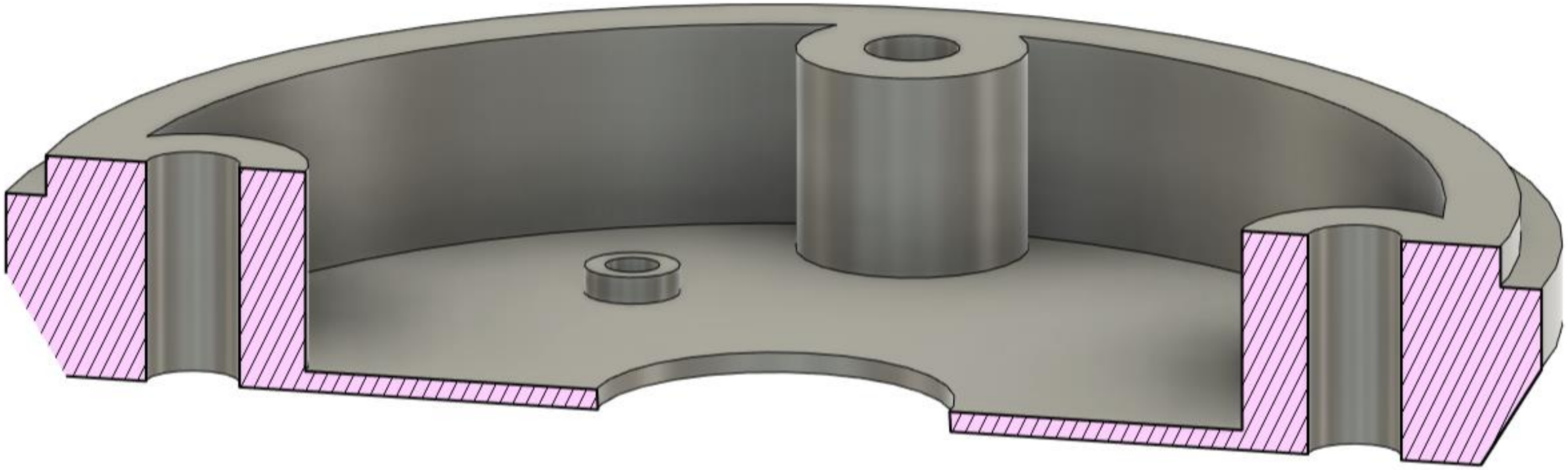
To overcome this challenge, a novel approach was employed. The nozzle was redesigned to be printed in two separate parts. This approach was inspired by a third-party add-on for the open-source 3D printer slicing software "Cura". The two parts were then joined together to form the complete nozzle.

Benefits of this Approach

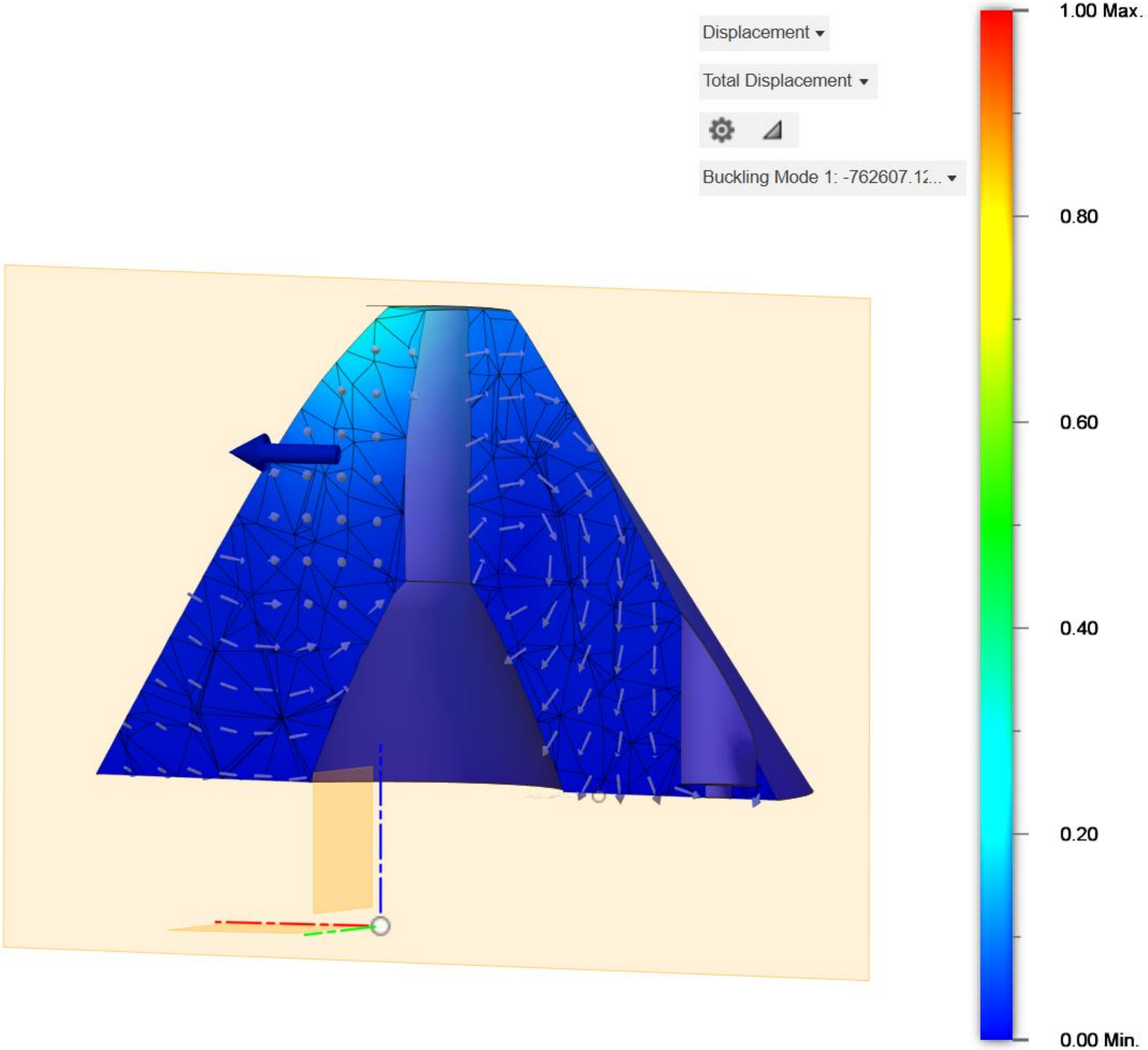
- Reduced the need for support structures, saving time and material.
- Improved the accuracy and surface finish of the final part.
- Enabled the production of complex geometries that would be difficult or impossible to manufacture using traditional methods.

Conclusion

The successful refabrication of the linear motor nozzle demonstrates the potential of 3D printing for repairing and restoring complex equipment. The innovative approach used in this project highlights the versatility of 3D printing and its ability to overcome manufacturing challenges.



FEA Analysis



Gimbals Upgrade

Hand Calculations

FEA

Personal Projects

Tennis Racquet Grommet

Objective was to boost power of Wilson Prostaff 90

Hand Calculations

FEA

AirPods Application