

University of Wales Trinity Saint David

School of Engineering



Engineering Design ACMA4008

CAD Report – Dry Sump Design Project

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1 Introduction

1.1 Introduction

In the world of motorsports Engine performance is paramount. A traditional wet sump is adequate for day-to-day driving. The dry sump system is the prevalent choice of enthusiasts and motorsport teams.

This report delves into the design of a dry sump system tailored for use in motorsports. A look into the principles of the dry sump system and its advantages over the conventional wet sump.

All aspects of the design are meticulously examined to ensure the product has optimal performance, durability, and reliability for use in most demanding race conditions.

1.2 Aims

The aim of the task is to design a suitable dry sump pan and oil pickup adapter for an engine that is intended to be used in motorsport. The customer requirements have been given as shown in Fig.1.

Customer requirement	Importance rating (1-10)
The product should be lightweight	8
The product should be easy to install (initial set-up)	5
In the event of a roll-over, the engine should not be flooded with lubricant	9
The product should be low cost	7
The product should allow easy/fast access for servicing/maintenance	7

Figure 1-Customer requirements and importance rating

As well as the customer requirements, Consideration is required into the functional requirements. These requirements could include improvements to the customers expected requirements and even include features the customer is not aware of or not considered.

2 Problem identification/ understanding

2.1 Understanding

Although the customer has specified their requirements. Further research shows that there are additional considerations that could further enhance the product.

Wet sumps are commonly used in motorcycles, these rarely suffer from oil starvation caused by lateral acceleration caused by tilting the motorcycle. However, when fitted to a race car on a horizontally. These forces can cause the oil pickup to no longer be submerged in oil causing a loss in oil pressure which can lead to catastrophic engine failure. (Shane McKenna, 2011)

A dry sump set up can benefit as the sump works by utilizing a scavenge pump to remove the oil from the oil pan and store in a separate oil tank making the oil readily available to be pump back into lubricate the engine internals. This is one of many design qualities that could help create a better product.

There is often the need to mount the engine as low as possible in the vehicle, resulting in a sump pan with limited height. During high-speed cornering a thin layer of oil sloshes around inside of the sump which is why baffles are used to maintain a continuous oil supply to the oil pump and prevent any air pockets to the oil pump. This can lead to premature wear. (SBD Motorsports, 2020)

It can be said that features not mentioned in the customer requirements that would benefit such as performance, durability, and functionality.

We can factor such things into the design. For this, a Quality function deployment (QFD) analysis will be used to map out the customer needs and engineering specification and determine the relationship between the entries using the house of quality. (Ullman, 2010)

2.2 Quality function deployment

Applying the QFD steps builds the house of quality shown in Fig.2. Each section containing valuable information that can help find where there are opportunities to improve the product.

Table 1-QFD house of quality (see appendices for full version)

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With the house of quality table Fig.2 complete, the weighting generated can now be used to help create our design specification. See section 3.

2.3 Competitor research

For the competitors, a comparative dry sump has been chosen also a conventional wet sump.

2.3.1 Competitor Dry sump



Figure 2-Nuke Billet Dry Sump Oil Pan Mercedes M104 (Speeding performance parts, 2024)

Fig.2 The competitor dry sump designed by Nuke billet (SBD Motorsports, 2020) Is made from lightweight billet aluminium, has 4 oil ports and is a has a shallow design with a sloped bottom to help with oil circulation.

2.3.2 Competitor wet sump

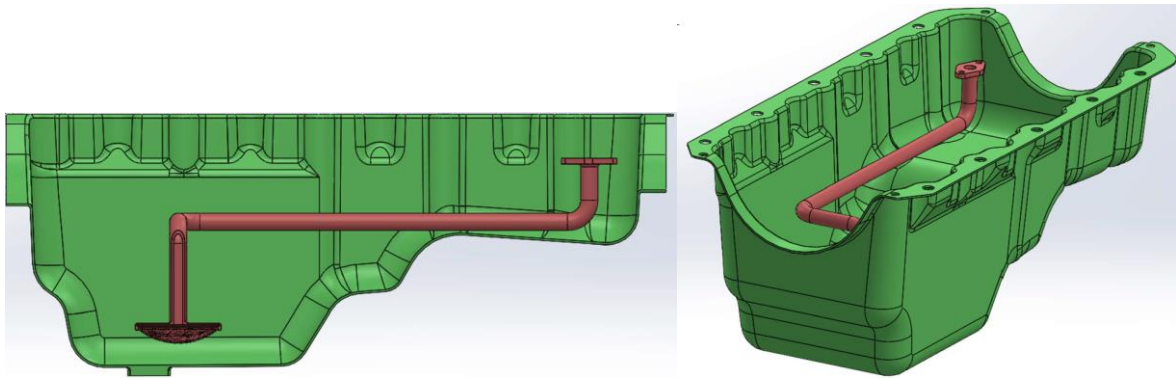


Figure 3-Wet sump model

The conventional wet sump. The preferred setup for day to day use in road going vehicles has many disadvantages compared to the dry sump. It's a larger unit which can also mean heavy, both of which is what motorsport teams/manufactures try to minimise to maximise performance. A benefit of the wet sump is the serviceability. With a simple drain plug for oil changes and a separate oil filter.

2.4 Learnings

After completing the QFD and looking at competitor designs, the information gathered can be used in the design specifications.

Features of both will be considered in the design specification and used in the design concept.

3 Design specification

There isn't an agreed-upon sequence of steps in engineering design. Scholars have described the design process in various ways. Ranging from 4 steps to 25. An inclusive design process typically begins with a conceptual design, which then leads to the generation of multiple potential solutions. Identifying the customer needs, Problem definition, Information gathering, conceptualization, concept selection, refinement, and design review. (Thramboulidis, 2010)

3.1 Dry sump design specification



Figure 4-Design specification for the dry sump

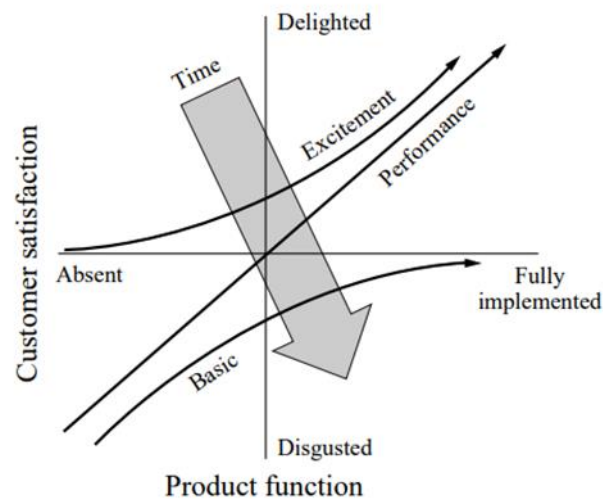
Fig.4 Is the design specification generated from the researched gathered. Key information will be taken into to the concept design process. Focus on the key areas from the knowledge and research gathered will help in the development of our design.

Key areas to incorporate are as follows:

1. Look to incorporate a good oil flow. This will help with power output, preserve the engine, and protect engine against failure.

2. A shallow lightweight design made from billet aluminium. Benefits include lower cost, weight saving, better mounting position of the engine for better performance and serviceability.
3. Ensure serviceability is possible to maintain the longevity of the engine. Will further enhance the product when participating in race events.

3.2 Kano model.



Graph 1 Kano model for customer satisfaction (Ullman, 2010)

Introduced in the 1980s by professor Noriaki Kano, the model revolves around the principles of quality. Offering a straightforward ranking system that distinguishes between essential and differentiating attributes. This model help visualise product characteristics and encourages discussion among teams. (University of Cambridge, 2024)

It's with this model that our gathered research and customer requirements are used. This helps build and understanding of what the customer is not only desiring but expecting as a minimum.

4 Development & presentation of conceptual designs.

4.1 Concept 1

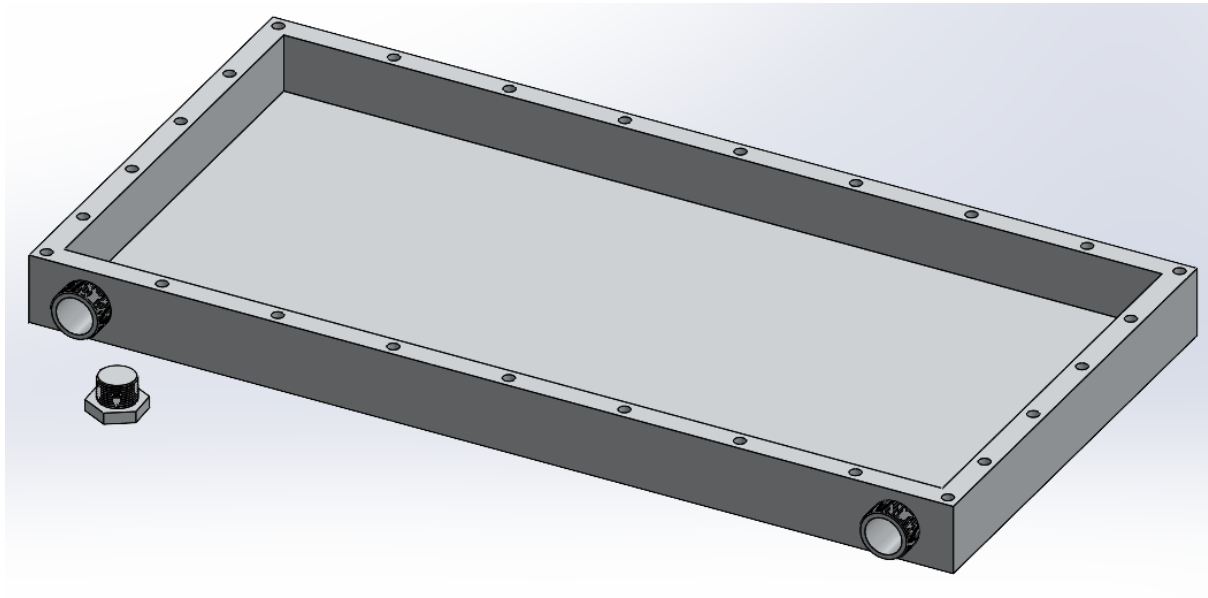


Figure 5-Solidworks design for concept 1 sump -Top view (Purnell-Whitehead, 2024)

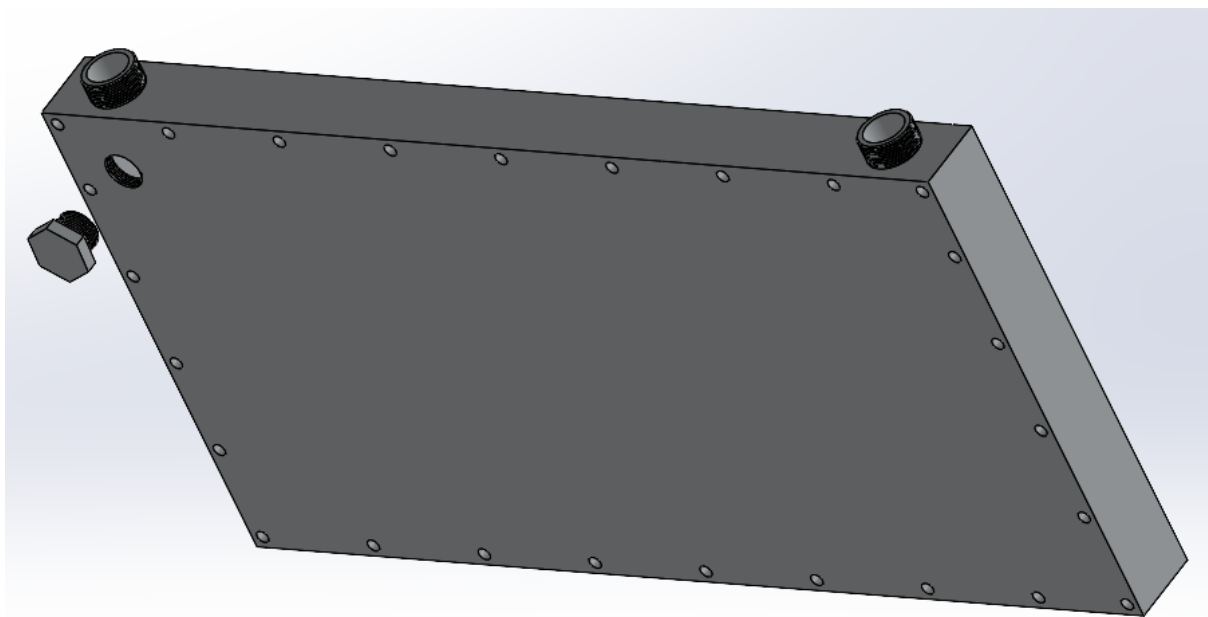


Figure 6-Solidworks design for concept 1 sump-Bottom view (Purnell-Whitehead, 2024)

Concept 1 shows a basic design. A good starting point. Listing the advantages and disadvantages and evaluating the results will help the second design.

4.1.1 Concept 1 advantages

- Two pickup adapter ports fixed.
- A shallow design.
- The ability to drain oil from the sump plug.
- The simple design will help with production cost.
- Easy initial setup.

4.1.2 Concept 1 disadvantages

- Poor oil flow.
- Chances of oil pooling.
- No help in preventing flooding should roll-over occur.
- Poor cooling attributes.
- No prevention of oil sloshing.
- Pick up ports fixed to sump.

4.2 Concept 2

4.2.1 Sump Pan

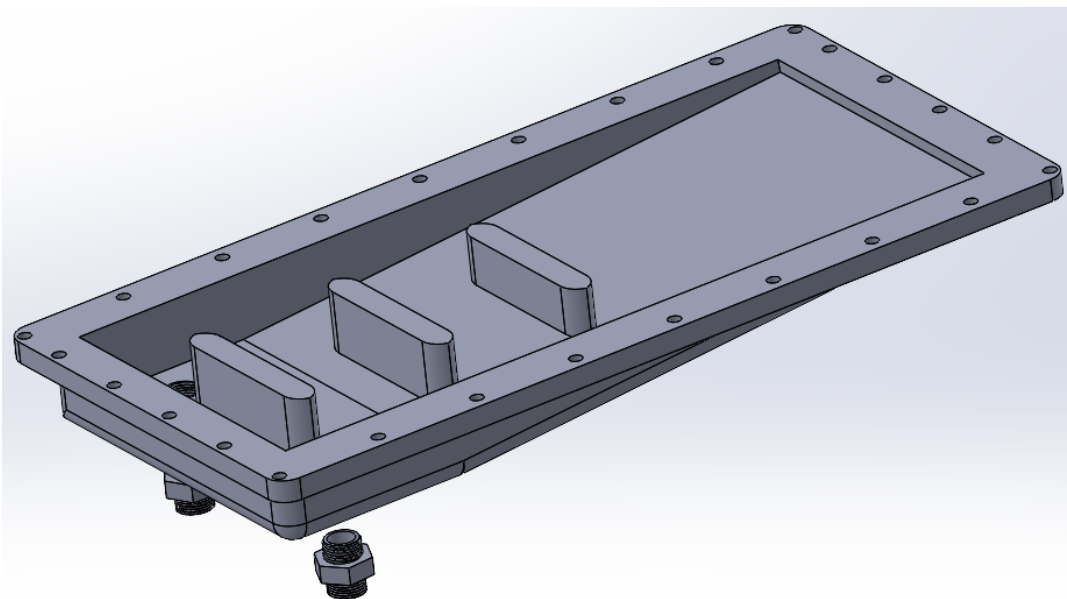


Figure 7- Solidworks concept 2 sump -Top view (Purnell-Whitehead, 2024)

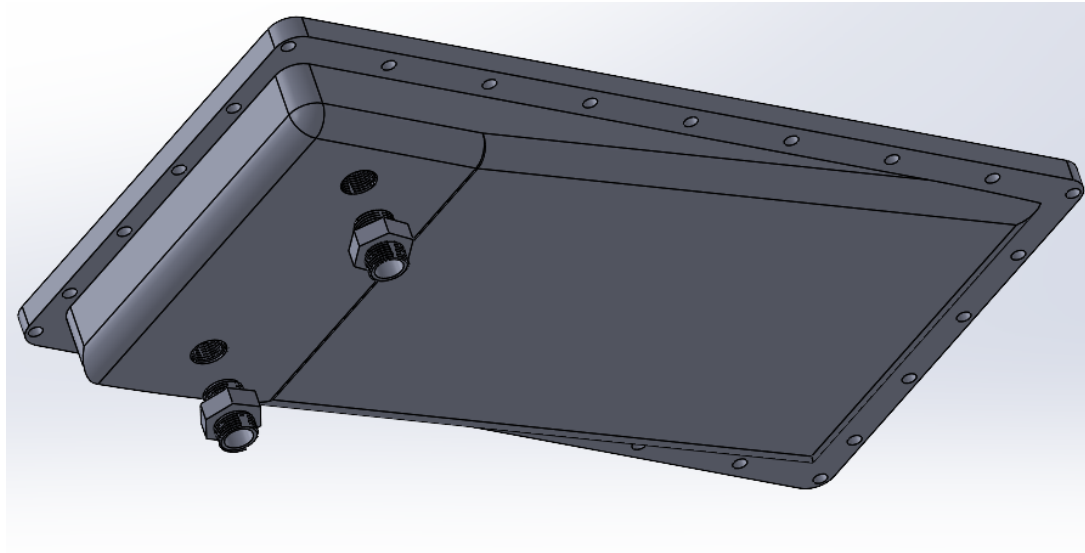


Figure 8-Solidworks concept 2 sump-lower view (Purnell-Whitehead, 2024)

4.2.2 Pick-up

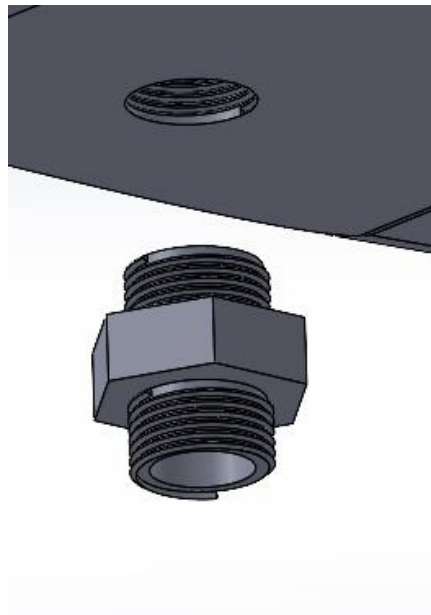


Figure 9- Solidworks Concept 2 pick-up (Purnell-Whitehead, 2024)

The second concept shown above in figures 7,8 and 9 show a further developed design. A sloping design will help guide the oil down towards the two pick-ups that have been placed at the lowest part of the sump. The pick-up has been designed as two removable components. This allows for increased serviceability. Although there is no separate sump plug. Being the lowest section of the sump allows the pick-ups to also be used as a drain hole.

The second concept also has baffles added. A feature to help with eradicating the sloshing of oil in the sump pan.

5 Final design.

5.1.1 Pick-up

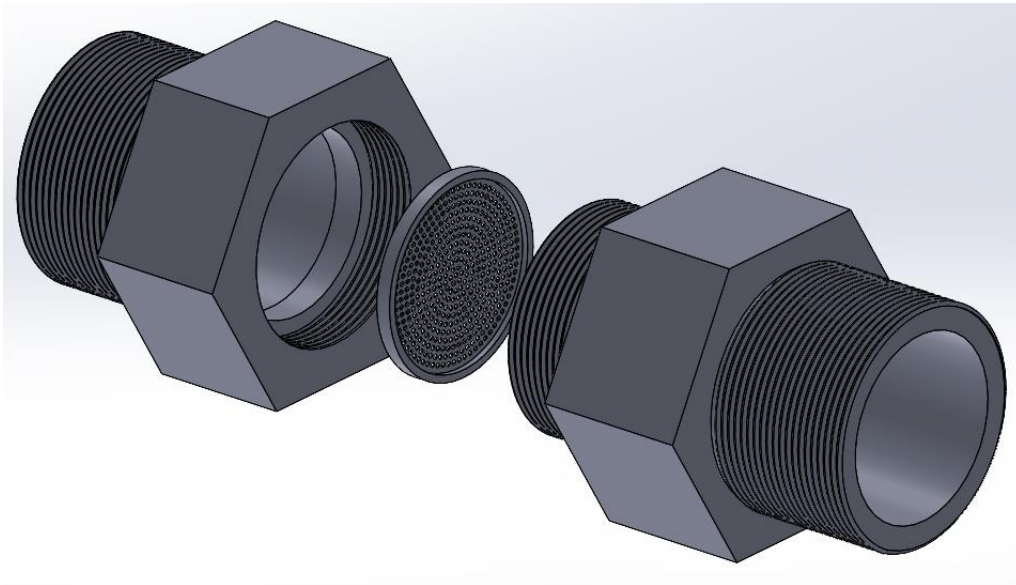


Figure 10-Solidworks Final concept pick-up (Purnell-Whitehead, 2024)

With the service and durability in mind. A gauze has been added for each of the pick-ups. This will help prevent any contaminants from reaching the scavenge pump. Also act as sperate drain plug for easy of oil removal.

5.1.2 Final concept.

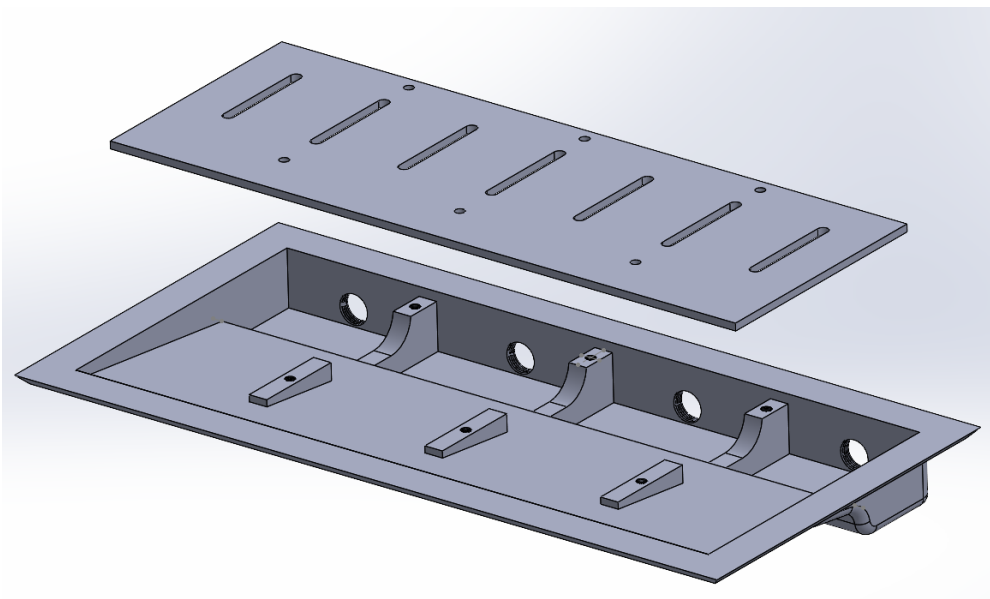


Figure 11-Solidworks final concept sump top view (Purnell-Whitehead, 2024)

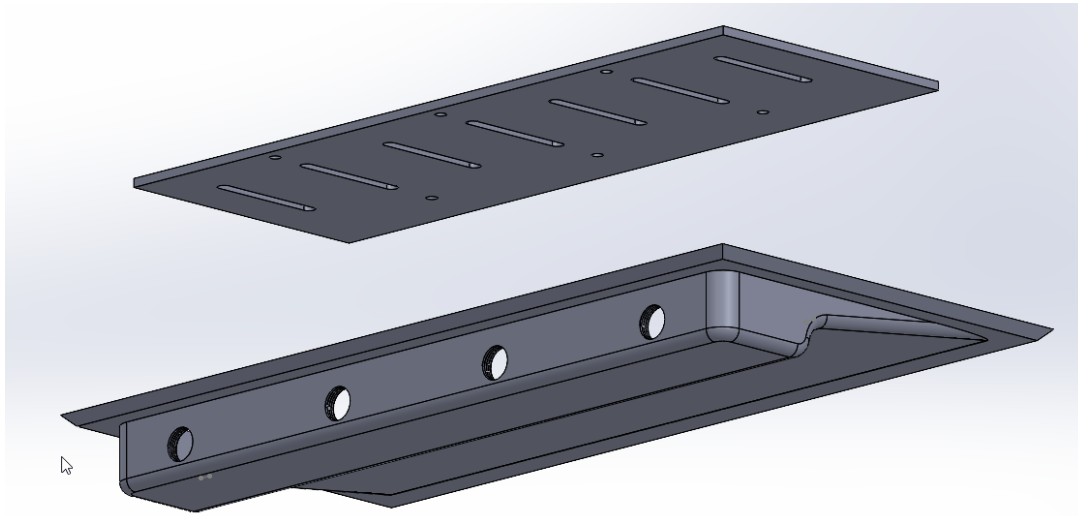


Figure 12-Solidwork final concept sump- bottom view (Purnell-Whitehead, 2024)

- After the final concept has been designed. Improvement through each stage is evident. The final design is heavily focused on durability and serviceability. Baffles to guide oil to the additional gauze fitted in each port. With initial setup cost likely to be higher to do the complicated design and additional features. It can be said that the design will provide long term service due to the serviceability and the features that can prevent premature wear on powertrain. Arguments can be made for the requirement of the baffle pan for flood protection. As the purpose of the dry sump is for no oil to be stored. In the event of roll over there will be limited oil to cause the damage.

Final advantages and disadvantages can be seen as follows.

5.1.3 Advantages

- Four ports aligned with each cylinder with dividing baffles helping to maximise oil scavenging from the pan.
- A slim design.
- A sloped design guiding oil to the ports.
- Incorporated baffle plate to limit oil flooding in case of roll-over.
- Pick-ups each with a gauze filter to prevent contaminants getting to the scavenge pump.

- Easy access to gauze filters for enhanced serviceability.

5.1.4 Disadvantages

- Complicated design.
- More components leading to more repair/service time.
- Higher cost due to more material and a more complicated design.

5.2 Technical drawings

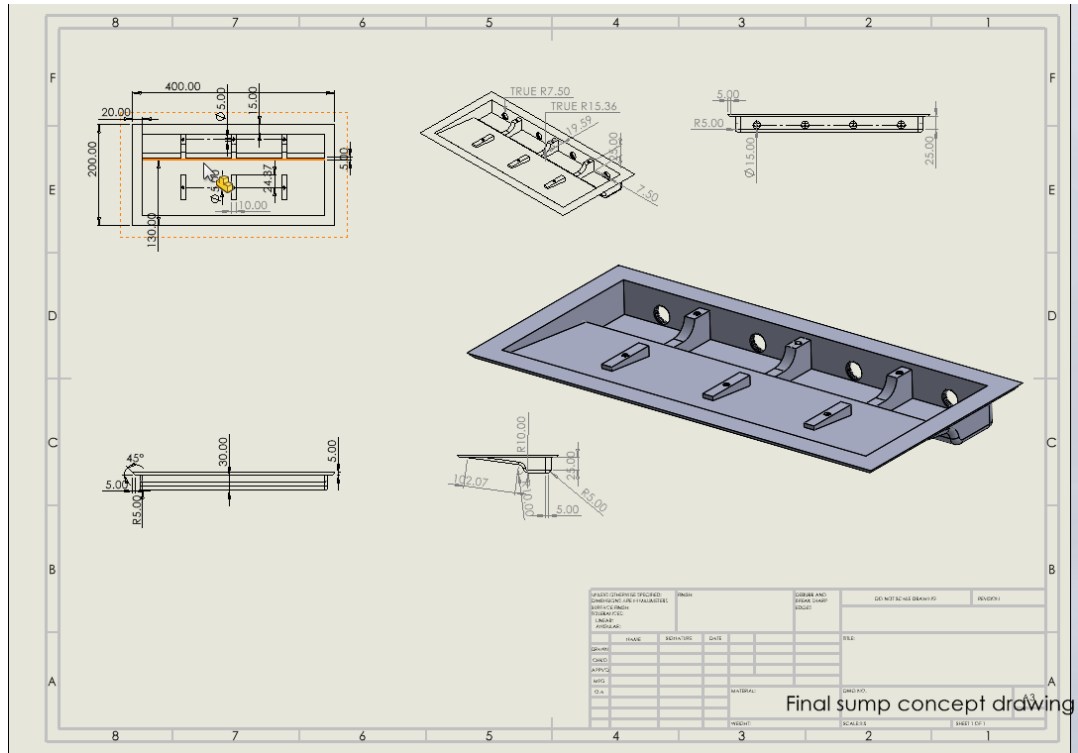


Figure 13-Technical drawing for sump pan final design. (Purnell-Whitehead, 2024)

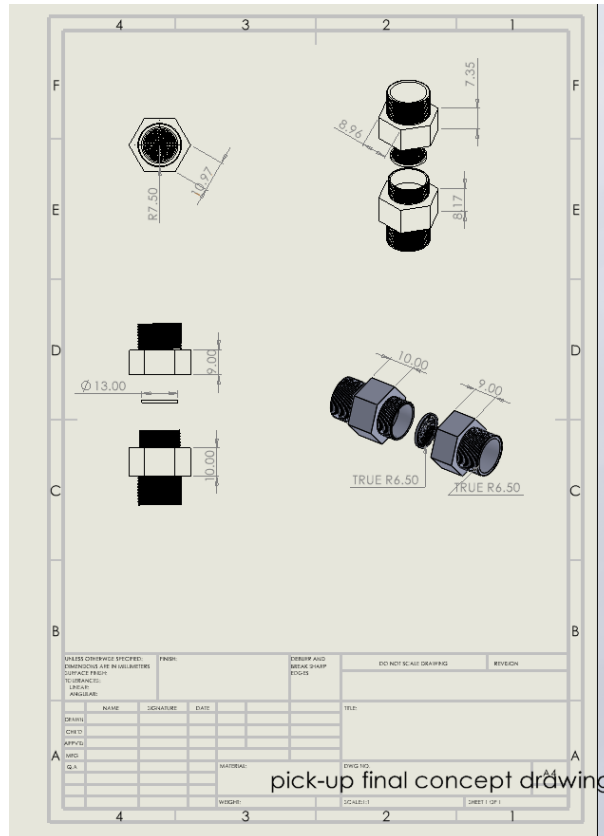


Figure 14-Technical drawing of oil pick-up final design (Purnell-Whitehead, 2024)

6 Evaluation

With the design finalised, the product will require testing to ensure it is fit for purpose. As the designs additional part that are part of the engine of a vehicle. It is intended that a prototype part is made. This can then be fitted to carry out such testing as bench tested on a rig or tested whilst fitted to a vehicle.

(Rishabh Khanna, 2019) Has carried out the testing for sloshing analysis. The primary objective was to guarantee that, irrespective of the driving conditions, there was an outlet linked to the scavenge pump providing access to oil within the sump. Also, that oil would be available to the oil pump.

(Shane McKenna, 2011) team incorporated a data acquisition system that logged various parameters during track testing. Logs of longitudinal and lateral acceleration, oil pressure and GPS position. Engine oil pressure would the be plotted against track position shown in Fig 15.

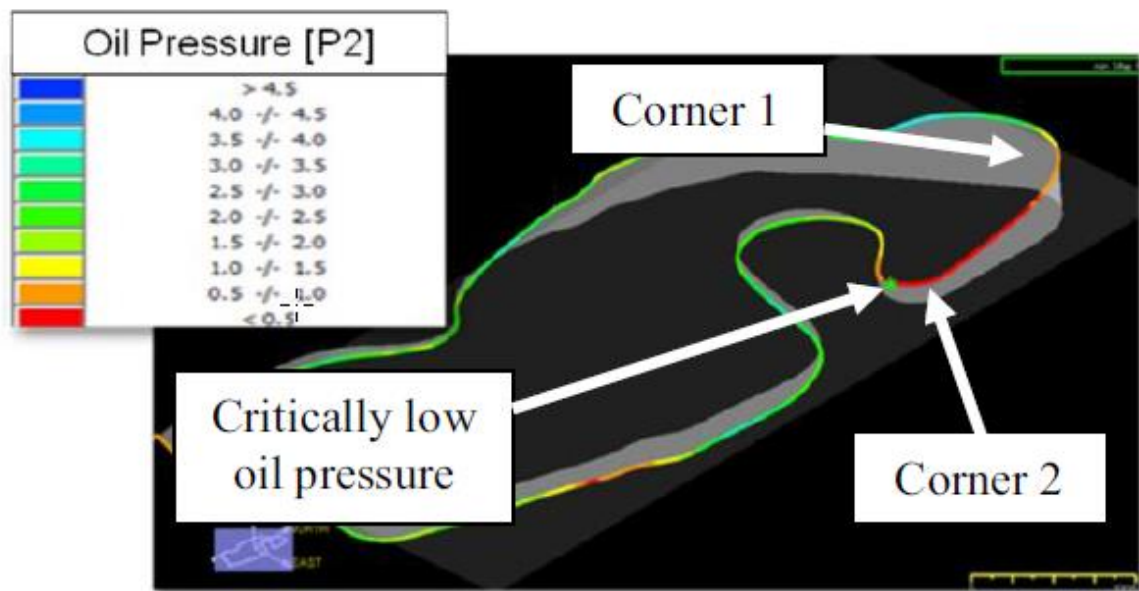


Figure 15- Engine oil pressure measured around track. (Shane McKenna, 2011)

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