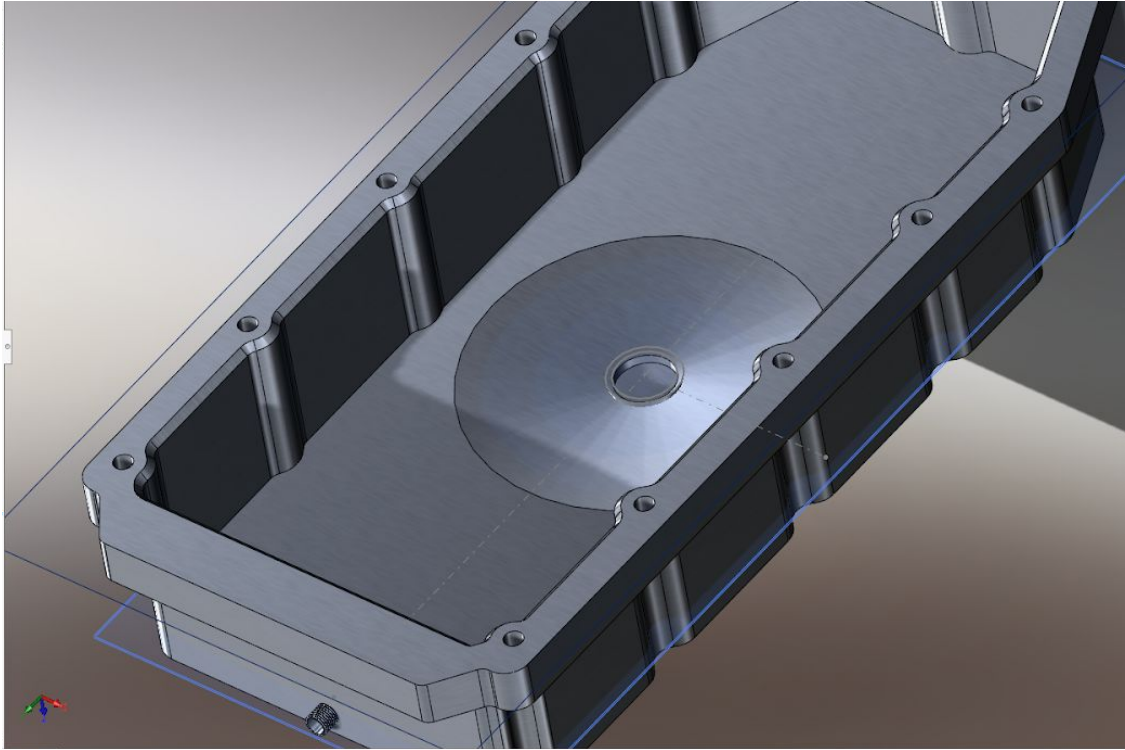




CAD Dry Sump

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Introduction

The aim of this report is to produce a dry sump for a Ford Zetec engine. The sump will be designed in solidworks. The software is capable of designing parts necessary for prototyping before putting into mass production. Navigating Solidworks-2019 requires a good level of understanding of it. When designing any product going on a car, the product will need to meet minimal set industry standards to need however it is also important to keep costs low. The sump will need to meet these standards as well as keep costs low, lightweight yet still be able to perform properly throughout the life of the vehicle. The design process will need to be carried out properly by creating draft designs and evaluating them along with a final design for the sump that will also be evaluated. Research into materials and their properties will also need to be carried out to determine the best material to make the sump from.

Research

What is a sump (oil-pan)?

A sump often referred to as 'oil-pan' is a metal dish that is attached to the bottom of an engine using screws. As the name suggests 'oil-pan', its main function is to hold the engine oil when the vehicle is switched off and also pump oil around the engine.

Wet Sump

A majority of cars employ a wet sump to handle the engine oil. The wet-sump is located below the crankshaft, depending on the carsize which will proportionately affect the size of the sump but in general a wet-sump is capable of holding 2-3 litres of oil. The wet-sump system works by pumping the the oil from the bottom via a tube around the entire engine.

Dry Sump

Dry-sump (oil-pan) stores the excess oil in an external tank rather than an attached sump such as a wet-sump which requires assembly with the engine. One of the main differences between the two is that a dry-sump has two oil pumps. One of the pumps takes the oil and transfers it to the tank while the other pump takes oil from the tank and injects it into the engine for lubrication. As a dry-sump employs an external tank, this allows the capacity to be adjusted per task. The disadvantages of a dry-sump system is increased weight and parts as the tank can be placed anywhere on a car, the extra parts leads to increased complexity and manufacturing costs.

In-order to create a durable sump that can handle wear and tear and one that is resistant to natural chemical change that would be experienced because of the atmosphere so choosing the right material is very important for that reason.

Materials

In order to find out which material is best for making the sump three materials will be evaluated:

- Cast iron
- Aluminium
- Stainless steel

Cast-Iron

- Widely used in industry
- High pressure and load rating
- High melting point at 1127-1204°C
- Heavy metal
- weak weight and tensile strength ratio

Aluminium

- Becoming more prevalent in industry as laws push for lower emissions
- High melting point 660°C
- Easily worked
- Numerous alloys with unique properties
- Can be anodised
- Excellent weight to tensile strength ratio
- Lightweight
- High load value

Stainless steel

- Low cost
- Easily machined
- Ductile
- High melting point
- Easily combined with other metals to create alloys
- Good weight to tensile strength ratio

Manufacturing methods

A big reason for the final cost of the sump will come from the way it's created. Methods such as CNC machining and die-casting are great methods to create the sump as they both offer accurate final product in-terms of its dimensions however. Computer Numerical Code (**CNC**) machines create desired parts by cutting a block of material via robotic control after uploading the design to its the machines accompanied software, it's like 3D printing but backwards.



Figure 1.0

Die-Casting is a great method because it is simple and it delivers consistent and reliable results and because of its simplicity the cost of manufacturing the sump using a die-casting method will drive down cost of the final product while still delivering a high quality engineered product.

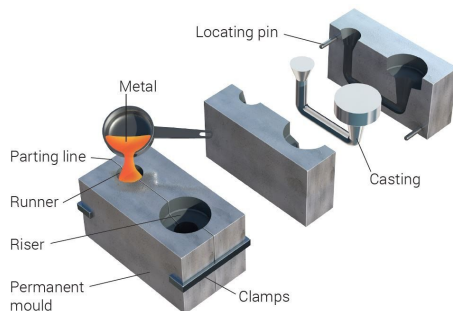


Figure 1.1

Selected

- Aluminium 6063 for its inherent characteristics
 - Corrosion resistant
 - Excellent weight to tensile strength ratio
 - Lightweight
 - Easily alloyed with other metals
- Die-casting
 - Low cost manufacturing method
 - Reliable / consistent results
 - Mould needed per sump
 - Simple technique, minimal computer control needed

Market Research

Table 1.0

Customer requirement	Requirement importance rating (out of 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

As the table shows, a big emphasis has been put on the factor that if the car was to roll over the engine should not be flooded with oil. Table 1.0 also shows that customers would like the dry-sump to be light lightweight which correlates to higher costs showing that cost was less of a factor in comparison. Customers were less concerned about the initial set-up cost because the customer themselves would be fitting the sump however the table does show that customers want a sump that would allow for quick maintenance/servicing.

Competitor Research



Figure 2.0

One of the sumps that is available on the market is the raceline Duratec-R dry-sump kit. Raceline has described their sump to have an internal pump which eliminates the need to accommodate a big external pump that would be on other models of the sump. Listed at £895 on the website.

Evaluation

Pros

- Purpose built
- lightweight/slim
- Wingbadge tray kit
- All parts included

Cons

- Expensive
- Capacity may suffer if oil is not replenished regularly

Figure 2.1



One of the other sumps available on the market that would fit on current zetec-engines is available on Drysump.com. On the website the company has boasted about that their version of the sump is made from aerospace aluminum alloy. This company shows how their product is machined.

Evaluation

Pros

- Good alloy which excellent inherent abilities
- Fits the Ford engine
- Good finish
- Machined to high precision

Cons

- Material may be overly engineered to necessitate its use
- High cost material
- High cost method of manufacture
- Big external pump

Methodology

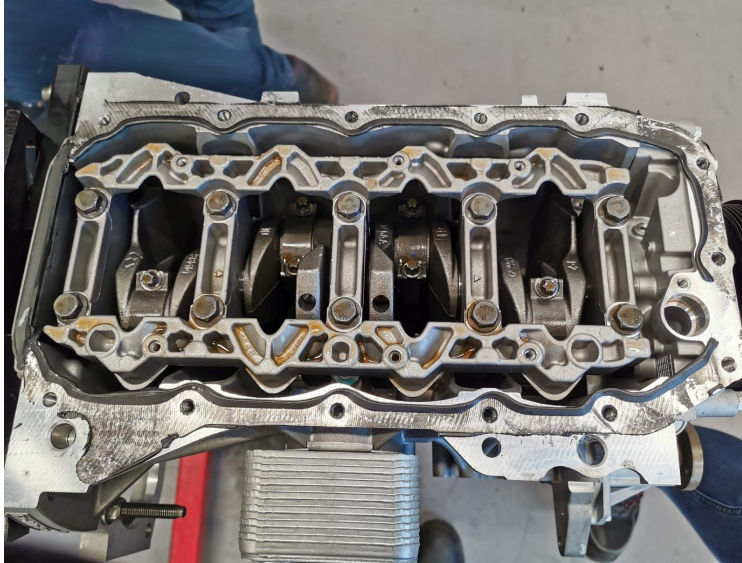


Figure 3.0

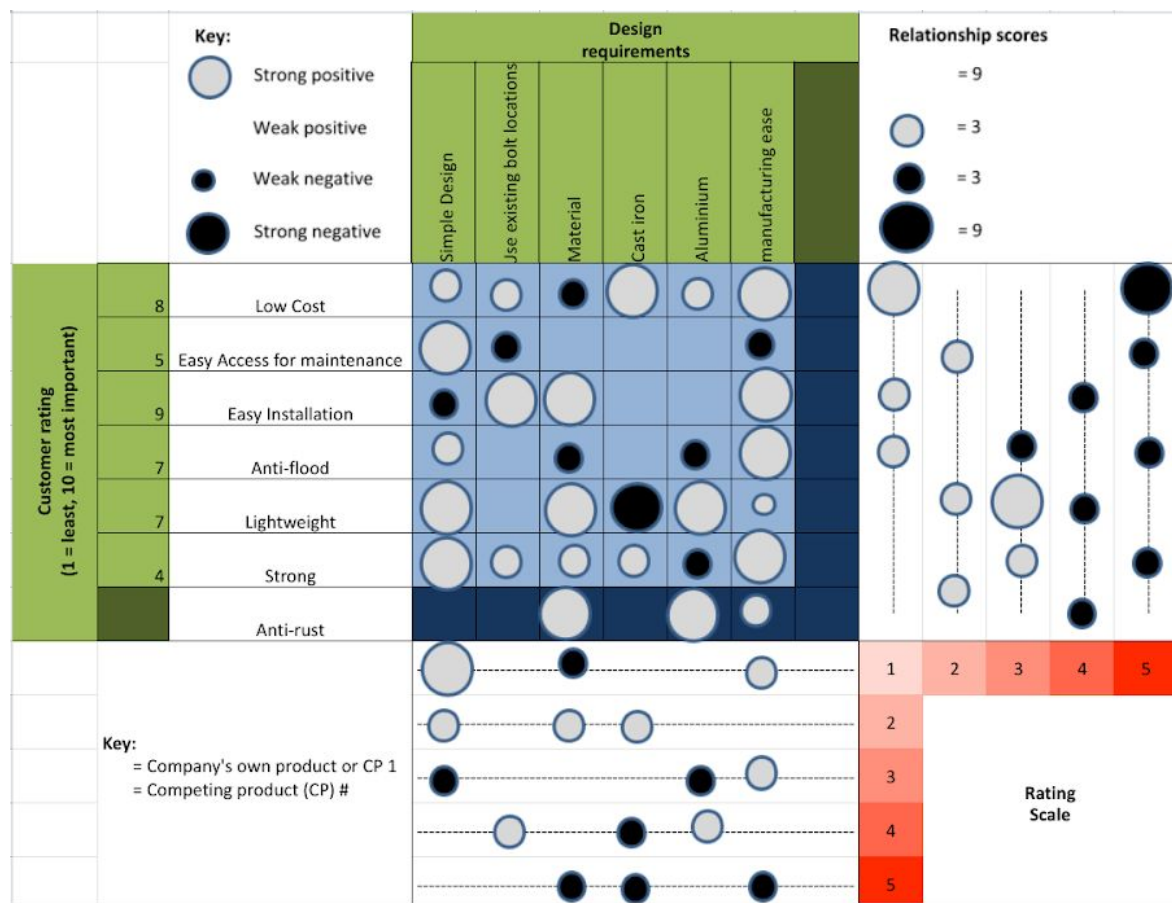
In order to create the sump for the Ford Zetec-engine as per the customer's order, a sump from a zetec-engine was obtained and measured at different points. These measurements were used to create the bolt locations and general design of the outline to create a sump that would fit perfectly on the current engines.

Product Design Requirements

Performance Requirements	Design Requirements	Design Specification
High oil capacity	Light weight	Total 13 bolt location
Must stay secure to engine	Low cost	Weigh less than 5kg
Durable	Method of manufacture	One way valve
Anti-rust	Material	Unit cost < £300
Withstand high/low temperatures	Ability to dissipate heat	Size of sump

Quality Function Deployment - Design specification

In-order to complete the designing process it is necessary to carry out a Quality Function Deployment (QFD). This is done to ensure a smooth planning, designing and prototyping phase as per the customers requirements and allows for the product to be compared to competitors which allows for a systematic approach to creating a product that can meet industry manufacturing and safety standards.



The final sump will be based on the design requirements found in the QFD. The QFD also shows the competitors product comparison as well.

Design drafts

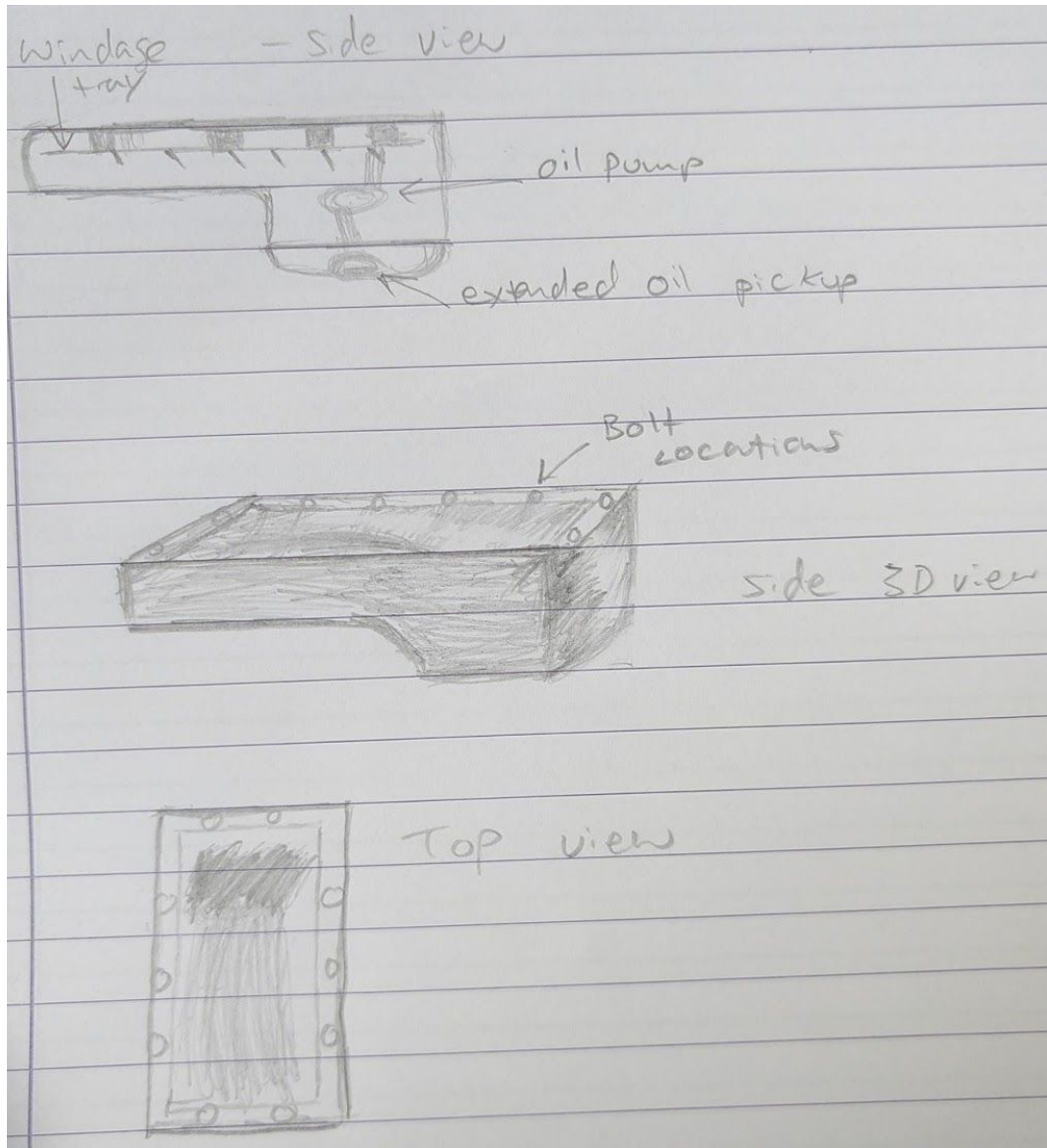


Figure 4.0

This is the first of the draft designs. This design was not chosen because of its inherent design flaws. This sump would be made of cast iron which is heavy and not what customers want. The design would also disqualify it would not fit properly in the space when attached to the engine. This design would not prevent the engine being flooded with oil if the vehicle was to roll over. The oil reservoir is also small and would not accommodate enough oil for prolonged journeys which may cause the engine to overheat.

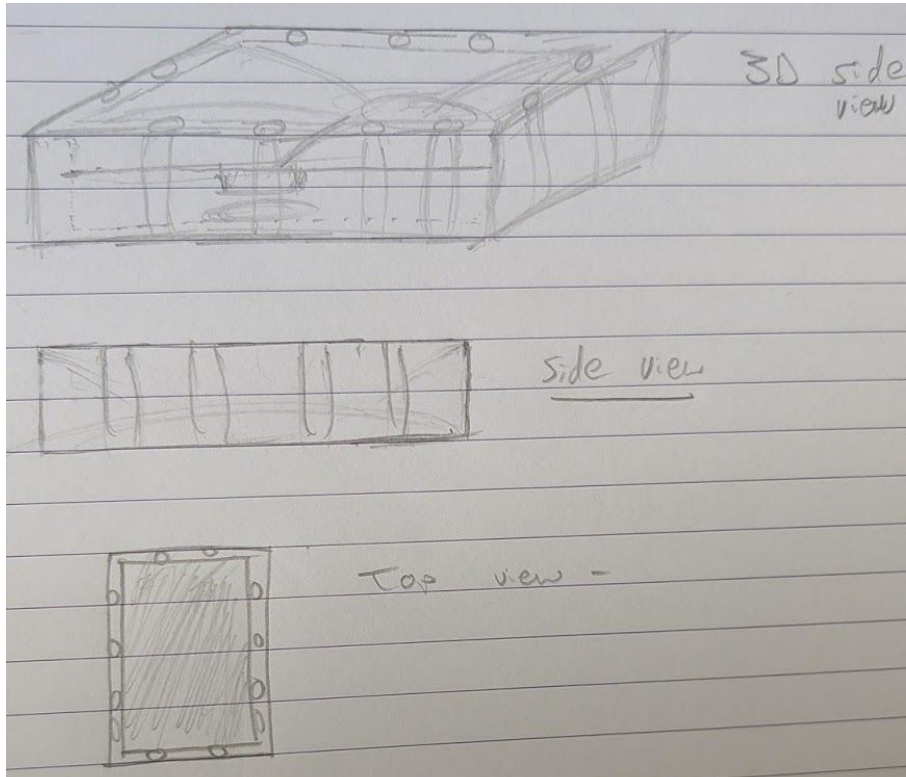


Figure 4.1

The second concept design is an improvement, it has the right general shape to enable a secure fit around the engine. It is a simple low profile shape which would allow for easy maintenance. This sump would be made of aluminium alloy and manufactured using a CNC machine. It has a large oil capacity for its profile that would allow for prolonged engine usage however this design does not have anti-flood measures.

Final Design

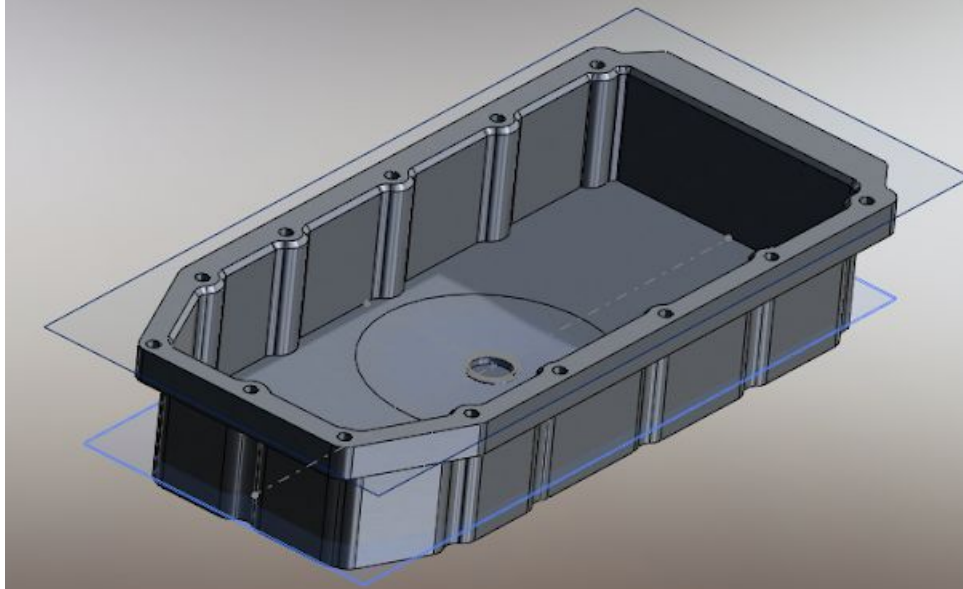


Figure 5.0

The above is the final design of the sump that has been created using 'Solidworks'. This sump has the correct bolt locations that would allow it to easily be attached to zetec-engine. The sump also has measures to stop the engine from flooding if the vehicle was to roll over. The sump has been die-casted out of aluminium and has a brushed finish for a clean aesthetic.

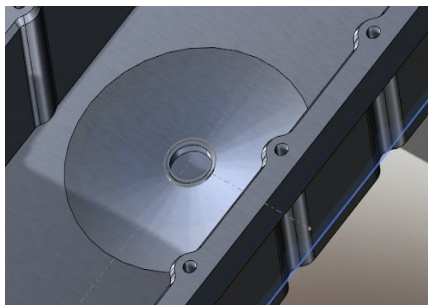


Figure 5.1

The middle of the pan is chamfered in-order to get oil to drip down into the space below to prevent flooding.

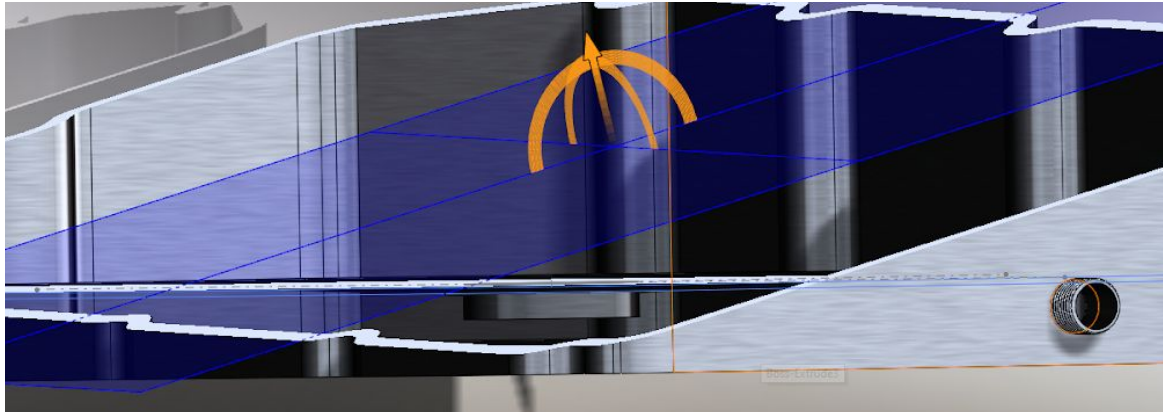


Figure 5.2

Using 'section-view' in Solidworks the inner details of the sump can also be observed. The lip that is extruded is there so that in an event of turning the oil would stop at its side which would limit oil leaking. This is space below that has been engineered to hold excess oil. The **One-way valve** system with threads can also be observed in this picture.

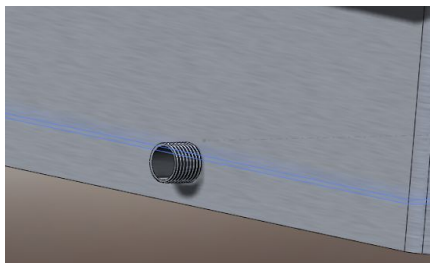


Figure 5.3

The sump has a one way valve system which prevents the need for a big external pump. In this set-up this valve is each to deal with when oil needs to be changed whilst still providing the ability for the sump to be adapted as a scavenge pump.

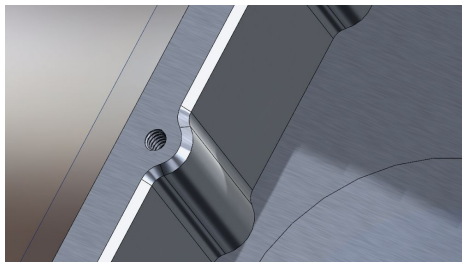


Figure 5.4

Bolt location holes have threading to allow a secure with with the engine.

Property	Value	Units
Elastic Modulus	6.9e+10	N/m ²
Poisson's Ratio	0.33	N/A
Shear Modulus	2.58e+10	N/m ²
Mass Density	2700	kg/m ³
Tensile Strength	240000000	N/m ²
Compressive Strength		N/m ²
Yield Strength	215000000	N/m ²
Thermal Expansion Coefficient	2.34e-05	/K
Thermal Conductivity	209	W/(m.K)

Figure 5.5

Technical properties of Aluminum alloy 6063
This image shows the loads al-6063 can handle

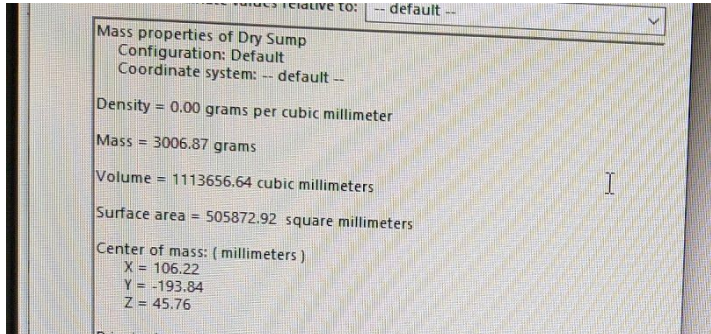


Figure 5.6

This image from solidworks shows information on mass, volume, surface area and Center of mass of the sump in its final form.

As can be seen from the image above, the sump is merely 3kg in mass which is great because customers wanted a lightweight sump were keen to have that as the most important factor from the market research.

Conclusion

The final sump has been designed to be a lower cost alternative for the customer compared to the sumps available on the market. The designed sump is lightweight yet its durable due to the particular aluminium alloy which is also resistant to rust the sump has the same bolt location required to fit the zetec-engine. The sump has built in measures to stop the engine flooding if the vehicle happened to turn over. As the sump will be die-casted this brings the overall cost down which is important as this sump needs to be a better proposition for the customer. The simple brushed finish would also bring the cost down in terms of cosmetics i.e. the alloy used could be anodised to the customers preference however that would increase costs.

Recommendations

In order to create a solid piece of motorsport and automotive world, the best yet one of the most expensive ways is to use a metal 3D printer that leave no weak points on the sump however the need for 'sumps' will fade as electric cars are introduced f

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