IMPLEMENTATION OF DRY SUMP LUBRICATION SYSTEM FOR IC ENGINE

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Abstract - *Formula SAE is an intercollegiate design competition that tests the ability of students to finance, design, manufacture, test and race a Formula 1 prototype race car, sponsored by the Society of Automotive Engineers (SAE). We use the Triumph Daytona 675r motorcycle engine to power our car. We desired that the CG of the car should be lowered so that the dynamic performance of the car increases. To overcome the problem, we were assigned to design a dry sump oil scavenging system inside the Triumph Daytona 675r engine. We require that adequate flow rate is achieved in a small, lightweight pump assembly that will fit inside the crankcase without major modifications to the crankcase of the engine block. It must be easily manufactured. So, after surveying many products in the market we came across a pump with specifications. And with that we have designed an oil tank that will fulfill the oil requirement of the engine. Along with the tank we have reduced the height of the oil pan so that the engine can be lowered by 5-7cm. During their design sloshing effect was studied. They were designed in such a manner that they will minimize the sloshing effect and will not allow air to enter the oil lines.*

Key Words: **Lubrication system, Maximum flow rate, Length of housing, Center of Gravity, Scavenge Section Engine.**

1.INTRODUCTION

The Formula SAE is a competition in which the students from engineering background, design, build and compete nationally and internationally among different universities. One of the important rules of competition is that the allowable swept volume of the engine is 710cc that's why most of the teams install motorcycle powertrain systems into their respective vehicles. When the identical system is assembled in a race car one might get the issue with oil surging since the car is passing frequently from sharp corners with usually high speed. Although after the numerous designs were implemented, the full resolution had not come in every kind of scenario. A proposed dry sump system will significantly take care of the above issue. The primary obstacle for designing the custom dry sump is the efficiency that we achieved during the wet sump lubrication. The design procedure involves many steps in it right from selecting the design and simulating software's to the OEM components. To authenticate the whole design consideration, an EOP sensor was used to track the oil pressure during lateral and longitudinal acceleration. After succeeding the validations only 5 psi was seen on either side of the stock EOP values with a custom dry sump system.

1.1 Methodology

The designing of effective dry sump lubrication system includes two step process which are

1. Theoretical concept and calculation

2. Computational approach

Theoretical concepts:

[1] The underlying advance was to plan the dry sump dependent on the profile of the stock wet sump. The volume of oil contained in the framework should be circulated between the sump and the supply tank. The primary plan behind planning a dry sump is to keep a significantly more modest tallness of the engine when contrasted with the wet sump. The sump should likewise have two focuses through which oil would be sucked by the scavenge pump. All together to ensure the nonstop progression of oil through the search pump, we should guarantee that the oil is consistently present at the get point under every driving condition (corners, slowing down, and so forth) A few emphases of the sump configuration were arranged and sloshing examination was performed utilizing Ansys fluent. After an extensive measure of emphasis, the model with inclining focus was picked. The tallness of the dry sump is 55mm, which is a critical decrease from the stock wet sump.

Computational approach:[1] Sloshing Analysis A transient multiphase examination for smooth movement in the dish was completed on every one of the cycles which were conceptualized utilizing Ansys fluent and alterations were made in every one of these cycles from the past adaptation to improve results. The principal reason to perform sloshing examination was to guarantee, for a volume of liquid in the oil tank in all driving conditions there was an outlet which is associated with the scavenge pump which approached the oil in the tank. The alterations in each progression of plan emphasis were made remembering the stature of the tank.

1.2 Elements of Project

Pressure Pump: Used to pump the oil into the engine.

Oil Tank: It acts as an external storage tank for the engine oil.

Oil Pan: It collects the oil returning from engine parts which is collected by the pressure pump further.

Oil Hoses: It transfers the oil from the engine to the storage tank.

Oil Fitting: Used to make connections of the hoses with the components in the systems.

2. Dry sump lubrication system:

In the Dry Sump system due to the modified height of the pan, the oil is stored in the additional tank. This decreased height of the pan allows the engine to be at a lower height resulting in a lowered center of gravity. The oil tank is used to store the oil for lubrication of the engine. As there is no or very less oil in the pan, the effect of sloshing forming the layer of oil on the crank is nullified. The design of the oil tank is such that there is no starving of oil due to the sloshing effect.

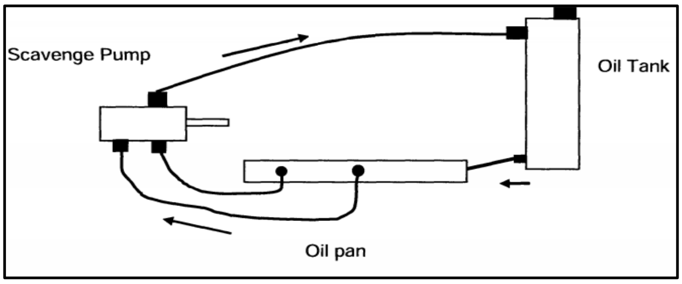

Fig -1: Layout of Dry Sump system

Dry Sump Lubrication System: In this lubrication the oil in the tank is pumped into the oil galleries and to the camshaft and other moving parts of the engine. An oil filter is used after the tank to avoid any damage to the pump due to the impurities present in the oil. The oil is passed through the oil cooler before going to the galleries and to the bearings. The oil is then collected into the pan (Sump) when it falls due to gravity and through the oil galleries. This oil is sucked through a suction pump and transferred to the oil tank.

Design of Oil Tank:

[7] *Volume of the tank:* The volume of the stock Wet sump of the Daytona675R was calculated and found to be 2.2l. The amount of oil required for the lubrication with stock sump was 3.3l. The Volume of the tank should be greater than the volume of wet sump, to compensate for the increased oil in extra oil hoses and to nullify the starving of oil due to lack of oil in the tank. So, the volume of the tank was fixed as 4.5 liters.

Material used for the tank: The material of the tank should have the following properties: low density, good machinability, weldability and should sustain high temperatures of oil. Aluminum (6061) has good mechanical properties and exhibits good weldability. It is also cost efficient and available in the local market. Considering the above requirements, we finalized Aluminum (6061) for the oil tank.

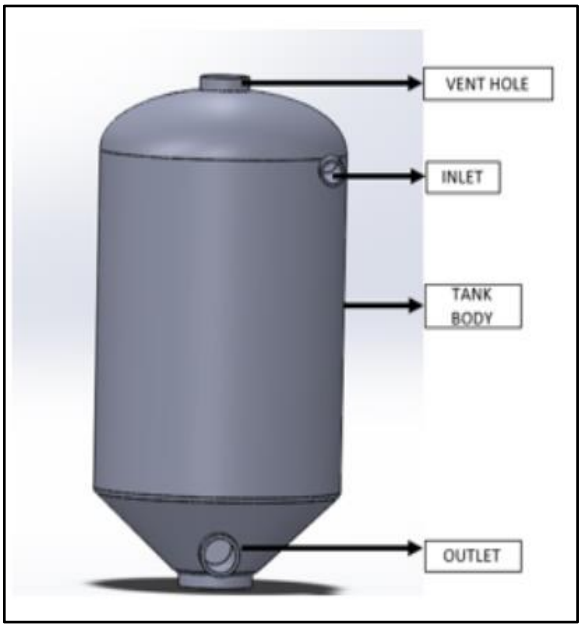

Fig -2: Oil tank 1

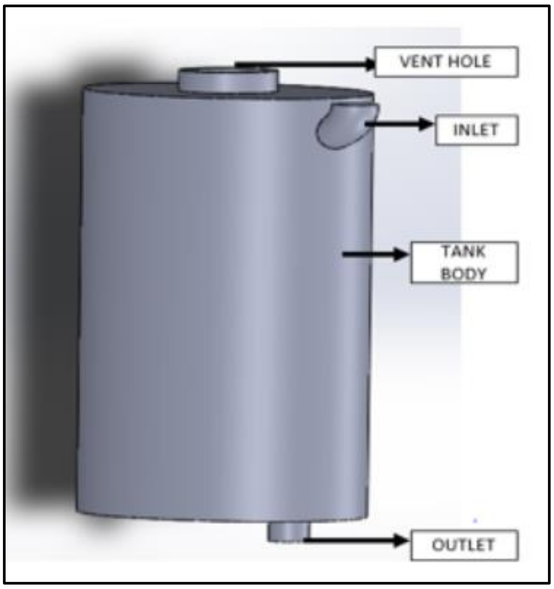

Fig -3: Oil tank 2

Shape of the oil tank: Considering the previous analysis of the research papers and the space constraints of the vehicle assembly of the components, we constructed three separate designs of the oil tank virtually using CAD modelling software. The CAD models are presented below.

Table -1: Physical parameters of oil tank

Total height	310mm
Capacity	4.1liter
Number of baffle plates used	2

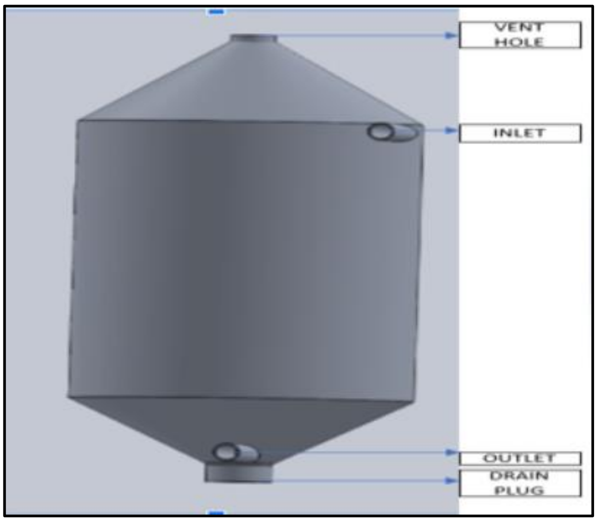

Fig -4: Oil tank 3

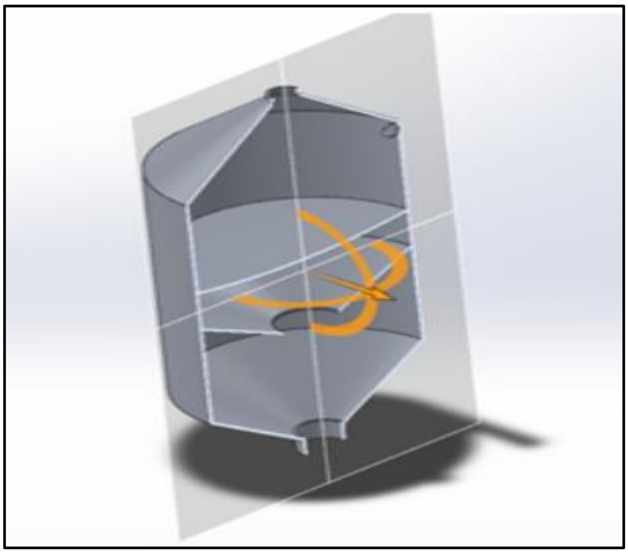

Fig -5: Section view of Oil tank 3

The sloshing analysis was performed to know the oil does not leave the outlet of the tank under the action of the acceleration, braking and cornering forces acting on the vehicle during a run. Peak conditions of the cornering plus braking force acting on the vehicle at same time was considered for analysis. The inputs to Ansys software were as follows:

Table -2: Input parameters used in the Fluent solver.

Volume of Oil during analysis	2 Liters
Lubricant Used	10W40 Fully Synthetic
Density of Lubricant	872.2 kg/m^3
Dynamic Viscosity	0.057172 Pa-s
Kinematic Viscosity (cost at 100 C)	14.9 cSt
Lateral Acceleration force	1.7g
Braking Force	1.2g
Material of tank	Aluminum 6061

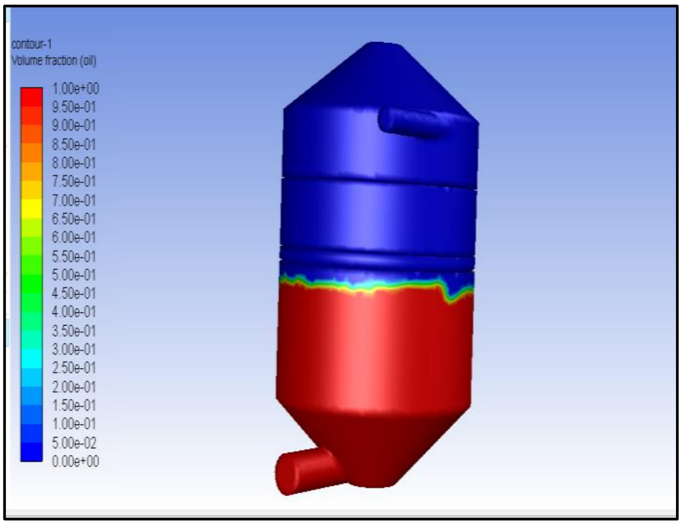

Fig -6: Sloshing analysis of Tank

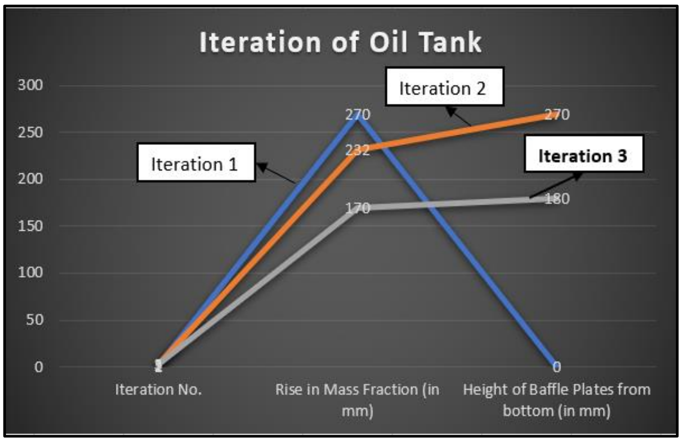

Chart -1: Iteration of Oil tank.

Oil Pan:

Problems with Stock Oil Pan:

Utilizing the stock 160mm deep oil pan, the target vehicle CG height cannot be achieved. A higher CG height will in turn lead to decreased performance in competition, which is not desired by the team sponsor. This oil pan is used because motorcycle operating conditions vary greatly from Formula SAE race conditions. A dry sump system cannot efficiently recover engine oil in these conditions because losses in oil pressure and oil flow are caused and are detrimental to the engine. In previous years, oil that collected in the pan was gravity fed to an external oil scavenge pump using the oil pan seen in Figure 1, below. This has driven the team to design a completely flat oil pan with no outlet channels used in previous years.

Modified design of oil Pan (Sump):[4] The design of the oil pan should be such that it has a lower height than the stock oil pan. On the basis of the mounting points of the stock sump, the mountings of the modified design were fixed.

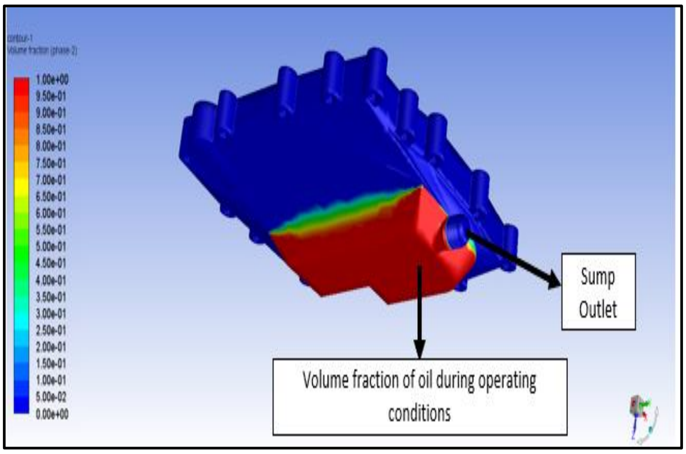

Fig -7: Sloshing analysis of Finished Oil pan.

The pick-up point for the suction pump was placed such that it is at the lowest point. Volume of the pan (Sump) was decided to be 1.3l on the basis that the oil in the oil galleries is 1.3l O(approx..).

Table -3: Physical parameters of oil pan

Physical parameters of the Oil Pan	Values
Volume	1.3 Liters
Height	55 mm
Material used	Aluminum 6061

Oil- Pump

Oil-Pump Calculations Given below, is the procedure for calculating the oil flow rate according to the given specifications of the stock pump and reduction ratio to the crankshaft rotation Triumph Daytona 675r. The stock pump used is a trochoid gear type which operates mechanically. As per the known stock design the rotor clearance cavity volume is 2cc and the rotor has 4 teeth. Hence multiplying the number of teeth with the clearance volume gives the total volume capacity of the pump to be 8cc per rotation. Proceeding forward the reduction ratio is known, which is the relative speed of the pump with respect to crankshaft rotation. Oil pump for Triumph Daytona 675r Scavenge Pump: Scavenge pump is one of the main components in the Dry sump lubrication system. It is used to return oil from the sump to the oil tank. For transferring high viscosity fluids, Positive displacement Gear pumps are used. Gear pumps have the ability to produce high vacuum and efficient pump heads can be obtained even by transferring high viscosity fluids. The pump will be mounted to a connector rib to mount it to the area of the water pump.

Scavenge Pump Calculation:

The stock pump utilized is a trochoid gear type which works precisely. According to the known stock plan, the rotor leeway depression volume is 2cc and the rotor has 4 teeth. Hence, increasing the quantity of teeth with the freedom volume gives the all-out volume limit of the pump to be 8cc per pivot. Proceeding ahead, the decrease proportion (reduction ratio) is known, which is the general speed of the pump as for the driving rod pivot. Assuming the driving rod rpm to be 1000 for less monotonous computations and duplicating it by the decrease proportion (reduction ratio) which is known to be 0.50, we get the speed of the pump, i.e.,500 rpm for every 1000 revolutions of the driving rod. Since the pace of volume dislodged per revolution of the pump is 8cc. At 500 rpm the pump will convey 4000 cc per mi. Peak engine RPM=14000. Therefore, at 7000 RPM (pump) the required flow rate will be:56LPM considering safety factor, we have selected 2 times the required flow rate=112LPM. Line pressure to be maintained = ***2.06bar***.

Specification's pump:

1) Length of housing:1.50" scavenge section

2) Weight of pump: 2.6Kg

3) Maximum flow rate of pump:130 LPM

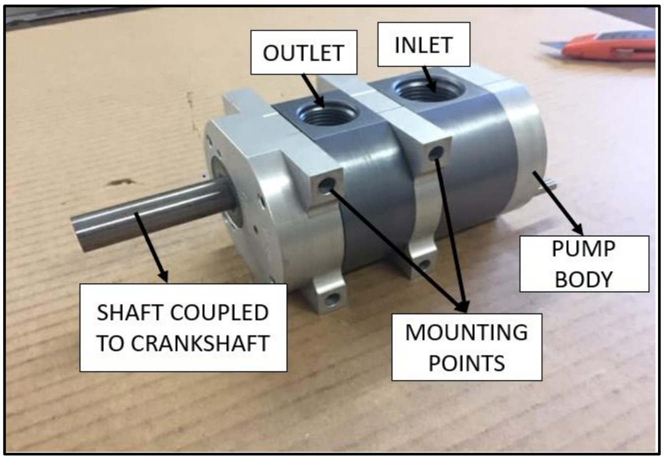

Fig -8: Oil-Pump

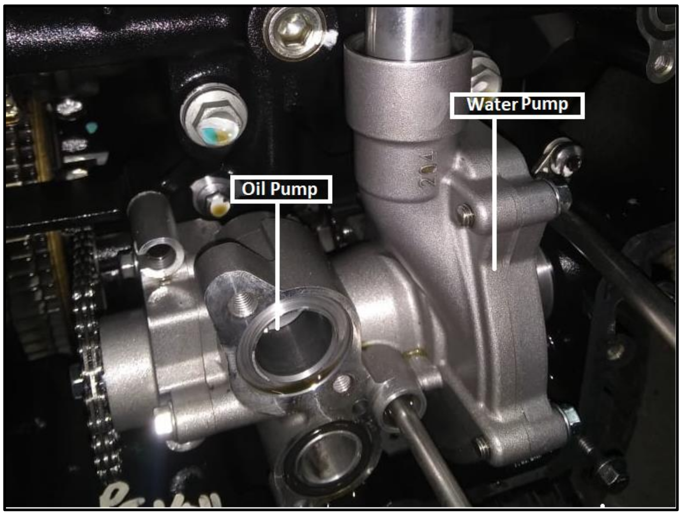

Fig -9: Stock Assembly of gear pump

Additional changes

Water Pump: The water pump is used to regulate water in the cooling system of the Engine. The efficiency of an Engine cooling system is directly dependent on the mass flow rate of water. Water pump plays a major role in the cooling system to maintain pressure in tubes for effective cooling. For our requirement we select an Electric water pump of 80 LPM. The Electric water pump of Davies Craig has a maximum discharge of 80 LPM. The reason of choosing Electric pump over mechanical pump are- As the Mechanical pump gets its power by rotation of Crankshaft, at the time of idling when the engine really needs to get cooled the pump gets less power which results in less efficient cooling, this problem can be overcome by using an Electric pump.

4. CONCLUSIONS

We have been assigned to design an oil scavenging system inside the Triumph Daytona675r engine. To solve the problems, we face when implementing a dry sump scavenge system. We desire that the CG of the car is lowered. . We have spoken to industry sponsors of the team and have determined to consider either a Gerotor gear pump system or a spur gear pump system. The team requires that adequate flow rate is achieved in a small, lightweight pump assembly that will fit inside the crankcase without major modifications to the crankcase of the engine block. It must be easy to manufacture, made using readily available resources and easy to remove and service. The housing material will be lightweight and easily machinable, and the oil will be routed through the holes in the designed oil pan to the engine and pressure pump. We have completed the tasks assigned. The component selection and packaging of the assembly as well as the oil routing have been addressed. We have built a final working prototype. Once results are logged and analyzed, we will proceed with in-car testing until the SAE competition.

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