IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 10, Issue 1, January 2020, ||Series -IV|| PP 61-70

Cleaning System Design For Autonomous Driving Of Car

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Received 02January 2020; Accepted 16 January 2020

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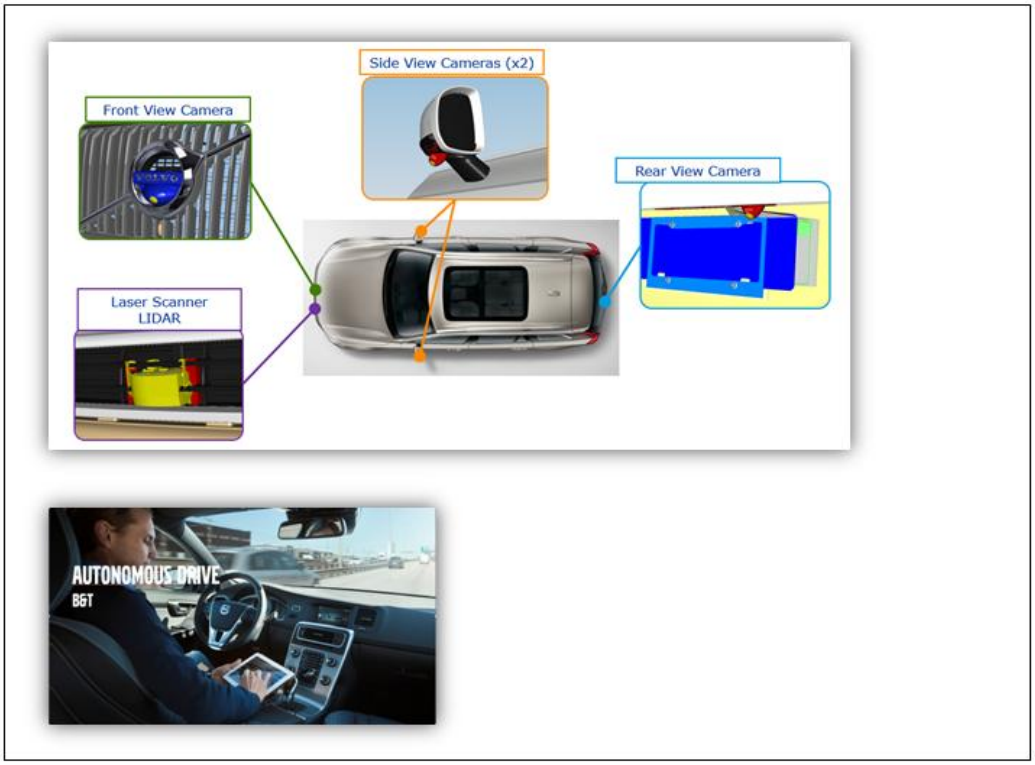
Need for the Cleaning system in vehicle :-

Volvo wanted to make one of its already on road vehicle, VCC42 to make Autonomous driving vehicle. To make this feasible 5 sensors were mounted on to the vehicle as shown below.For effective functioning of these sensors, a cleaning system that keeps them clean was required.



Requirements & functionality of Cleaning system : -

Similar to the purpose what wiper system does for windshield, this cleaning system is required to meet same purpose for the 5 sensors shown on previous slide

The Cleaning system shall store and transport washer fluid to the washer nozzles and deliver required flow and pressure to facilitate the cleaning of the 5 sensors. It shall be easy to fill the washer container without spilling. The system shall supply a signal to alert the driver when the fluid level becomes low. The washer container is an interface to the Sensors cleaning and washer fluid shall also be supplied to the sensor cleaning pumps which is mounted onto the washer container.

The washer operation shall not induce any non-intended disturbing distractions for the driver, visually and/or audible. The system shall function in its intended way throughout the vehicle's lifetime.

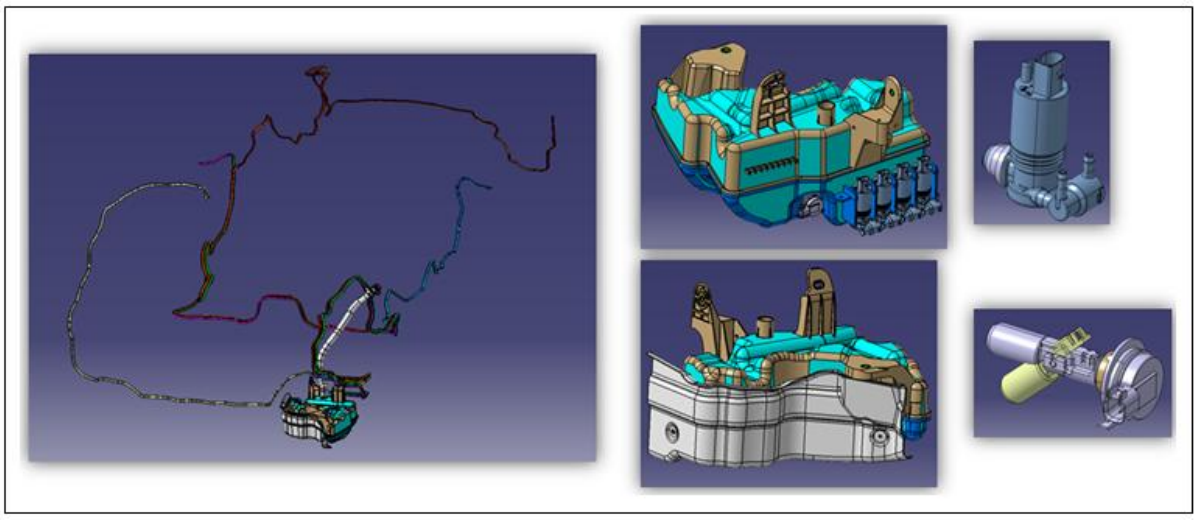
Challenges in the Design :-

- Obtaining sufficient space for the tank. It was stated to have minimum of 5 liters volume required. This space was required to be made available in the already designed on road running car – *The automatic driving system was mounted only in the petrol vehicle. This made the space occupied by Urea tank in diesel car available for packaging as urea tank is there in diesel vehicles only.*
- Sturdy fixing of this heavy tank in car –*Same fixations of urea tank were used for washer tank. It was fixed on to the floor body and tightly screwed there.*
- Easy filling of the tank from customer point of view –*The location identified was right below D-pillar post and ahead of the driver side rear wheel which made the routing of filler tube from fuel filler cap to washer tank feasible.*
- Defining position of the 4 pumps & the level sensor on the tank – *The design of pump holder was followed exactly like in case of wiper tank. It demanded to have some amount of flat land for packaging 4 pumps and a level sensor for which we compromised on losing some amount of tank volume.*
- Routing of its power cables and supply hoses –*This had to be done freshly and the existing apertures in car body and the wire routing were studied to define new routing.*

BOM of Cleaning system :-

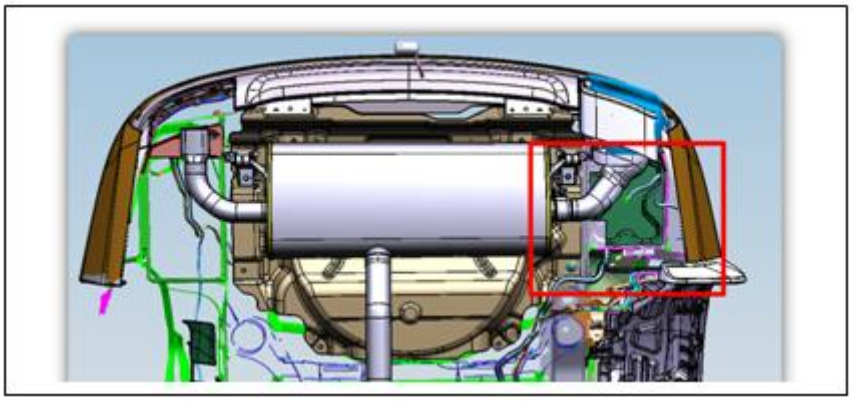
The cleaning system was required to have below mentioned components –

- A storage tank, material - Moplen EP340K, Part thickness = 1.8 mm, thickness at interfaces of pump and fixing brackets = 4 mm and thickness at interface of level sensor = 3mm.
- 8 hoses of Ø8 mm, material – EPDM
- 4 dual pumps
- 1 level sensor
- Filler pipe assembly - PP
- A heatshield was added later on as the position was found near to exhaust – Aluminium foil, thk = 0.8mm
- Fixings and bushes

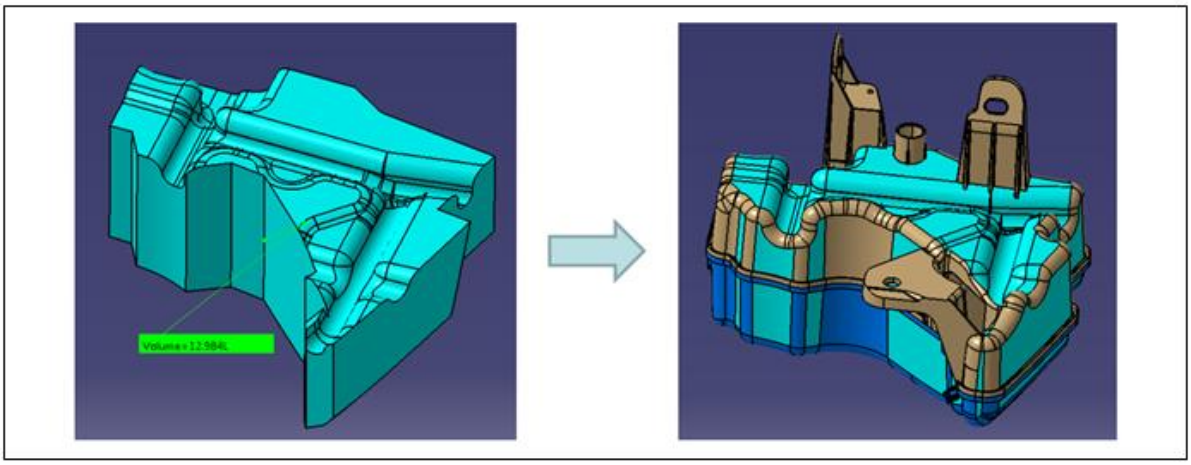


Progress of Project :-

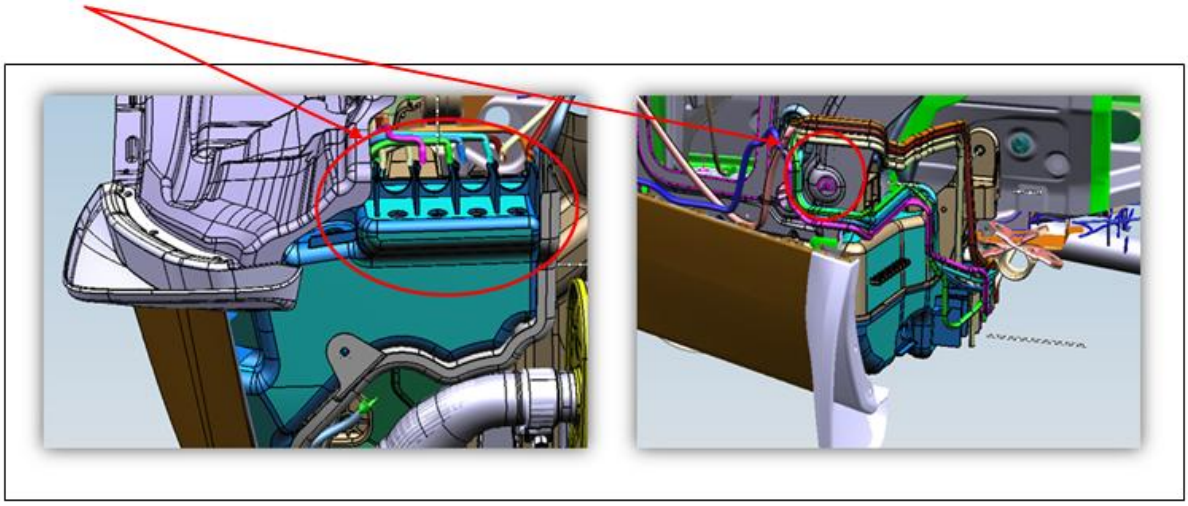
As a first step, we were required to find a space in vehicle already running on road.
The space should allow packaging of washer tank with sufficient storage + dual pumps and it should also be in a good position so that the pumps and sensors powering can reach there and also hoses should be easily routed to the different sensors.
Also there has to be provision for fixing the tank onto the BIW parts.
After some investigation below shown space was found available and was also good from every point of view.
The space was free as it was kept for Urea tank in diesel vehicles and autonomous driving was a petrol vehicle and hence doesn't require an urea tank.



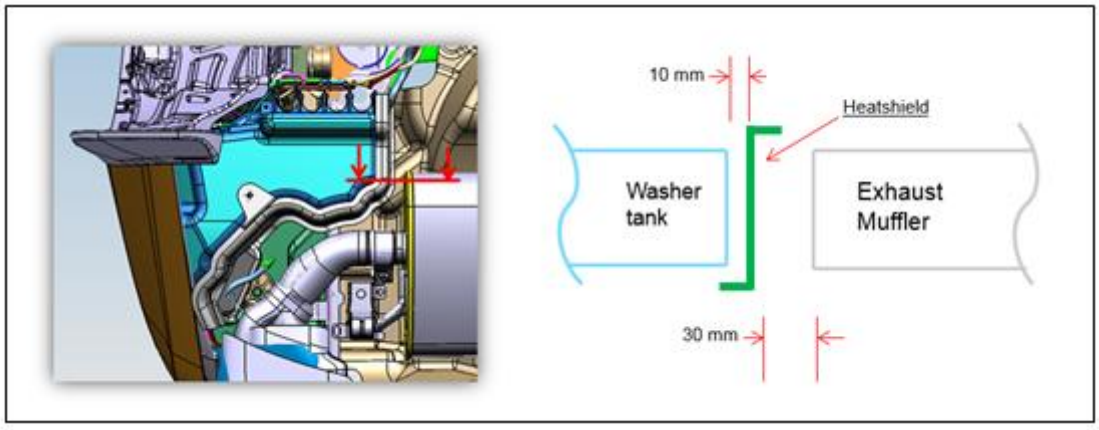
To study this space, we first created a raw block keeping minimum 10 mm clearance from every side and 30 mm from exhaust. The volume available was sufficient for minimum storage required.
The shape of block was then redesigned to form the 2 separate hollow halves of the washer tank which will be joined and sealed at mating boundary by use of vibration welding.
3 strong mounting fixations to fix tank on to BIW + an interface for inlet pipe + interface for holding the dual pumps and the level sensor - also were required to design.



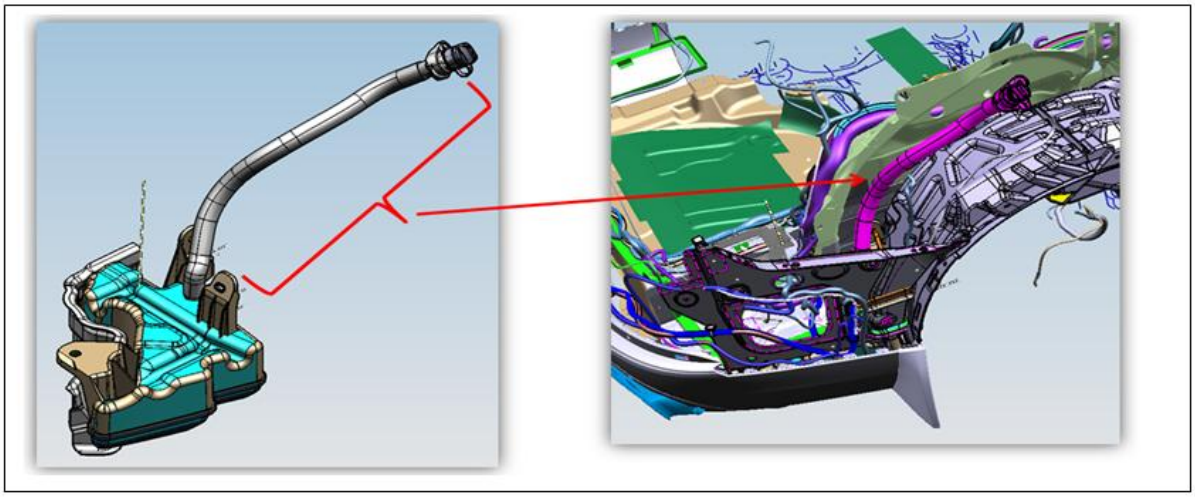
We identified the area towards the front side of the tank for mounting & packaging of pumps & level sensor. To package, it was required to make the some area as flat surface for which we had to loose some volume which was fine as this area was the optimal solution.
Also an already existing aperture in BIW in this zone made it easy for hoses coming from pumps to route them to desired sensors.



A heatshield was also required to design to shield it from exhaust system.
A guideline for the design and position of heatshield profile is as shown below in a section

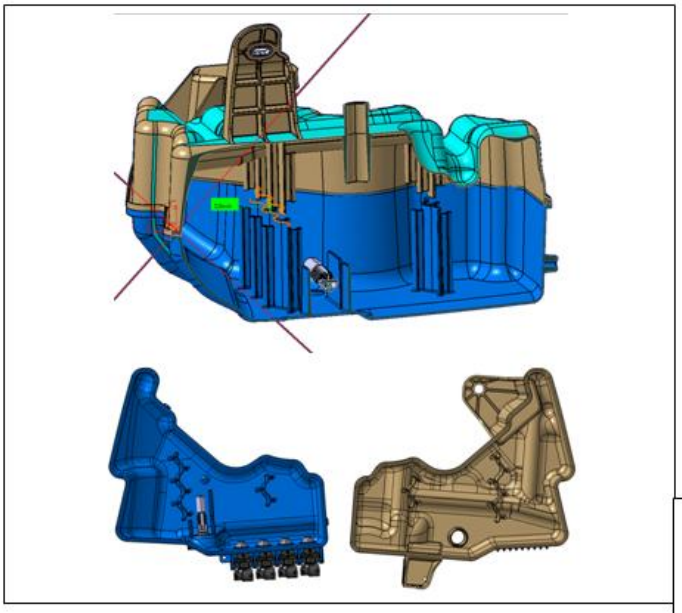


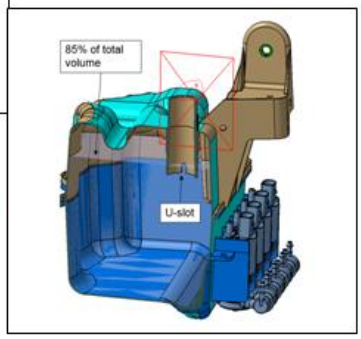
Filler function :- The filler pipe for Washer tank was used similar to the one for Urea tank with its end opening at fuel filler zone for ease of fillability.



Salient feature:-

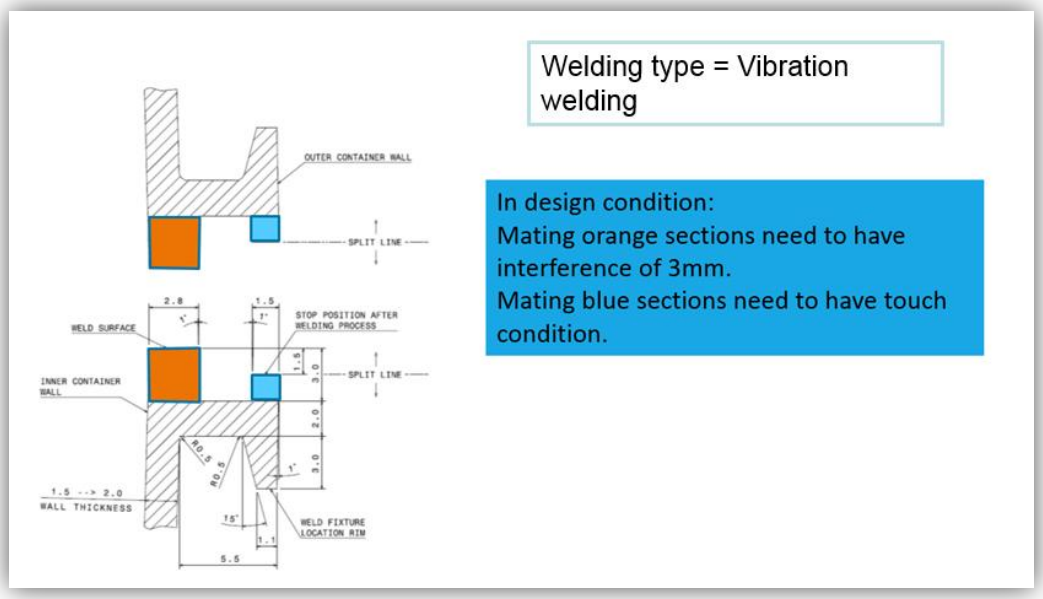
Anti Slosh rib:- The purpose of Anti slosh ribs is to reduce the internal impact of turbulence of the fluid when the car is moving.The 2 tower of ribs on either side in 2 halves of tank with a certain gap between them will disturb the flow of fluid inside of the tank and thus reducing the hydraulic force on the boundary wall of tank due to fluid splashing.



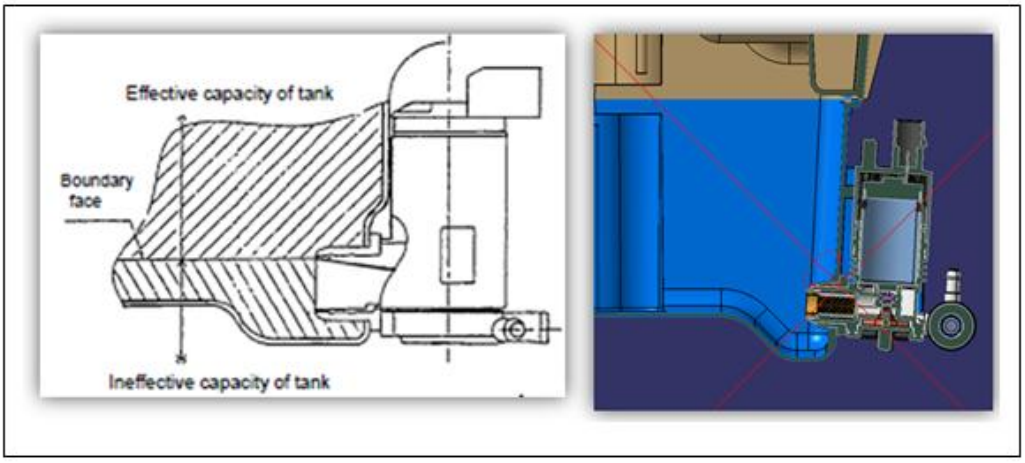


U-slot in filler opening:- The lower end of the filler pipe has to terminate at 85% of the total volume capacity of tank as shown in the section view. This is because tank requires air gap of 15% to allow for freeze thaw.However, this is an ideal condition achieved only when the car is not moving and fluid surface is stable.To assure this in real life, the lower edge of filler opening is lowered down a little beyond limit and the required 15% level is achieved by providing a U-slot to the pipe as shown.

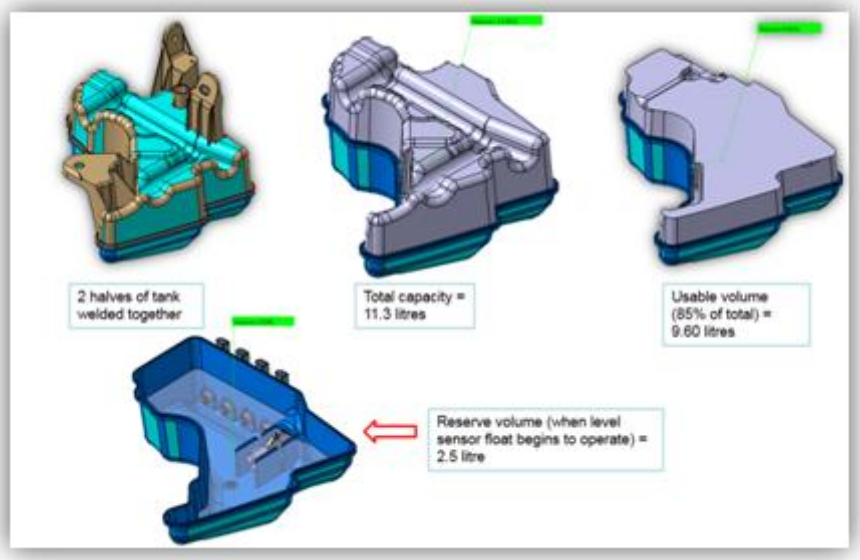
Welding type and typical cross-section:-



Utilisation of complete fluid:-To assure the complete utilisation of fluid, fluid volume below pump should be less than or equal to 5% of total volume. Boundary to be taken as top of pump inlet.

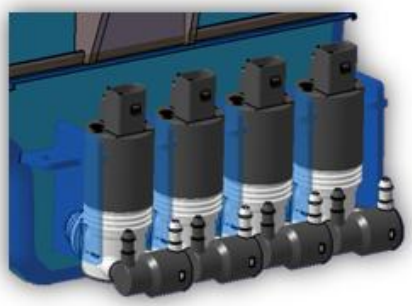


Volume capacity:-



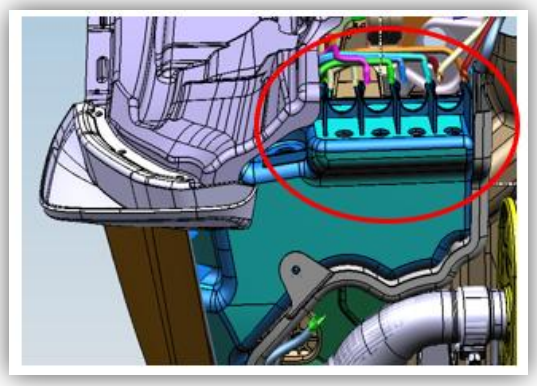
Pumps:- The pumps used for Cleaning system were the same pumps as used for Wiper assembly of Fr. Windscreen.
The pumps were dual pumps which means each pump was having 2 outlets.

Quantity :- 4 dual pumps were used alongwith a seal for each pump on insertion in tank. Hence there were total 8 outlets which were divided as - 5 as water jet for 5 sensors, 3 as Air blast.

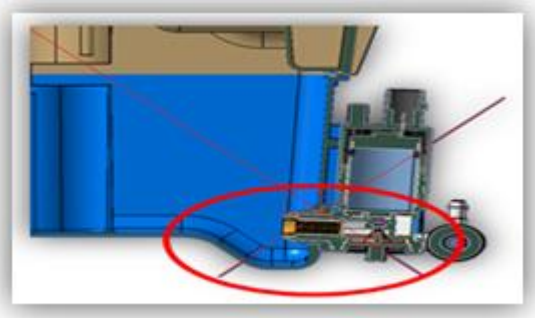


Design of holder: - The design of holder for pump was exactly like wiper tank pump holder. The pump body was having an interference fit with an interference of 0.25mm radially. Similar interference fit was designed between Tank hole opening to Pump seal.

Position significance: - The front portion of tank if made as a flat face was suitable position from the point of view of routing of both fluid carrying hoses and powering harnesses

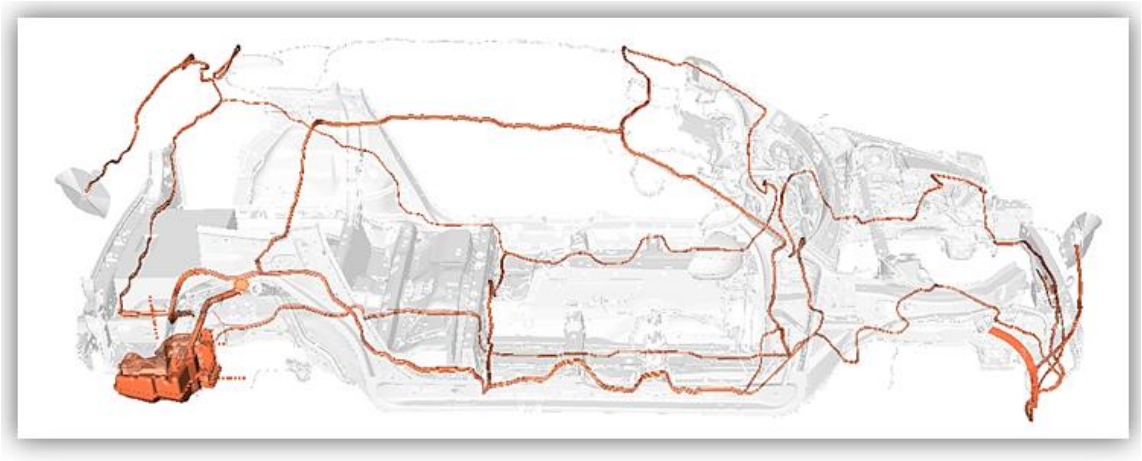


Position as per reserve volume: - The pump opening needs to be slightly lower than the bottommost point of tank to assure maximum utilization of available fluid in tank (5% can be the unutilized volume). This is achieved by lowering the pump and adding a recess as shown



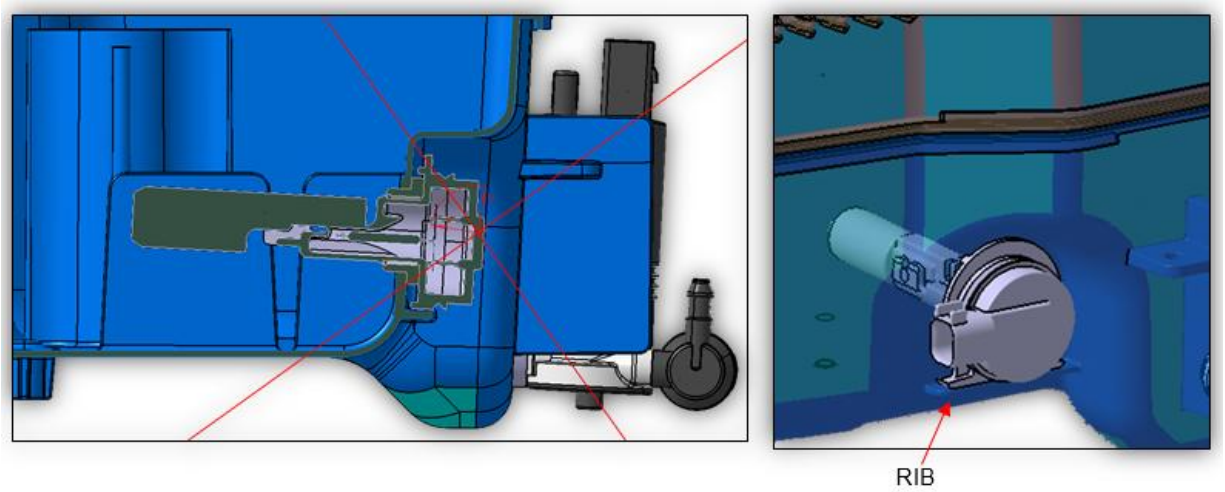
Hoses specification:- 8 separate hoses of Ø8 mm & Material – EPDM were used for connecting washer to bottle to different sensors. The tentative approach for washer-pump configuration was –

- Dual pump 1 to supply Front cam and Rear cam
- Dual pump 2 to supply Left and right outer side view cameras
- Dual pump 3 to supply Lidar and Air blast 1
- Dual pump 4 to supply Air blast 2 and Air blast 3

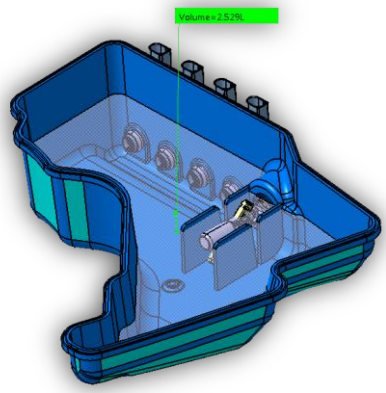


In total 30350 mm hose

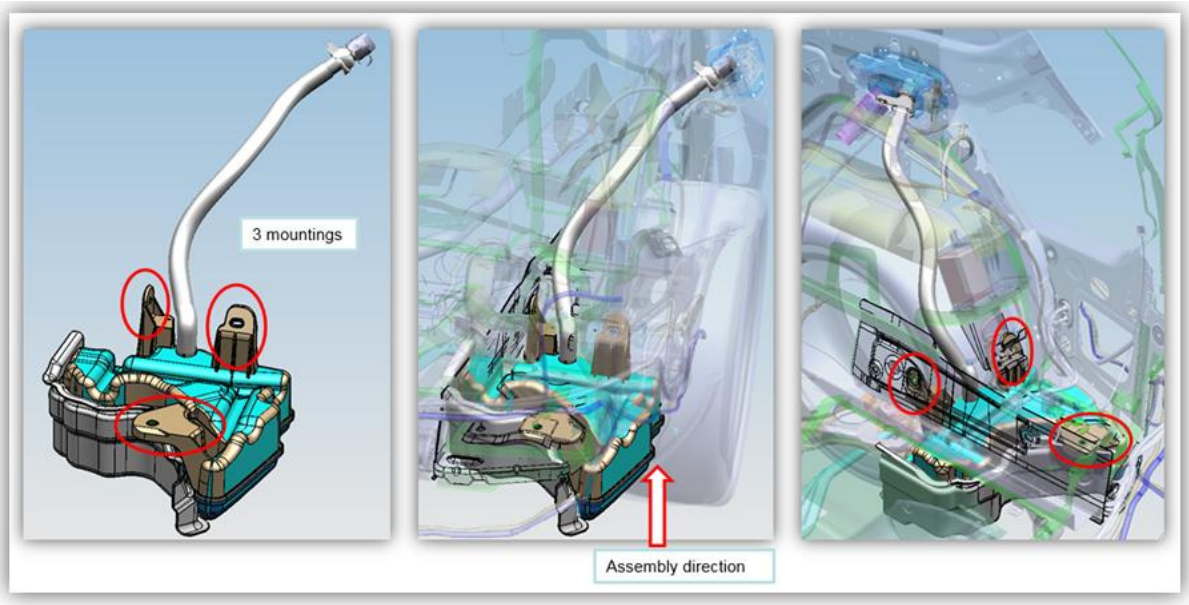
Level Sensor:- The level sensor was fitted on to the tank simply with the help of interference fit between the tank hole & the level sensor seal. A horizontal rib is provided for poka yoke purpose, so that the connector has correct orientation



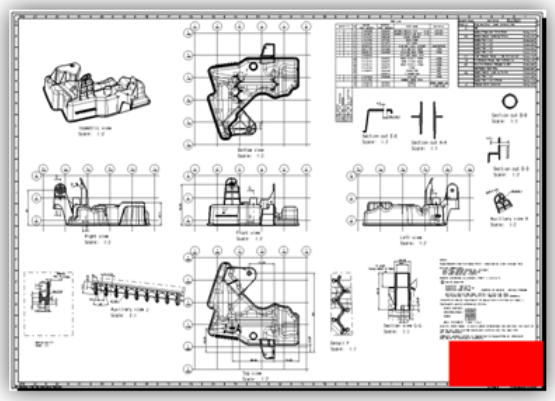
As shown in below image, level sensor was positioned so that the float begins to operate with at least 2.5 litre of reserve fluid. To have precise reading by the float, the tail end of sensor or the float was guarded by 2 walls on either side with a recess on that in between which would prevent err due to the slosh of fluid –

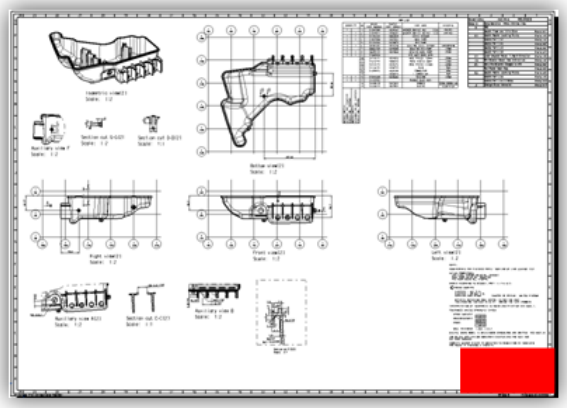


Mounting and fixing of tank on the car:- The washer tank was an under body part and hence does not have any locator, however only strong positive fixations.The tank is assembled on the car from the beneath and straight in Z- direction, while all the tank accessories viz pumps, bushes, heatshield and level sensor already fitted onto it.

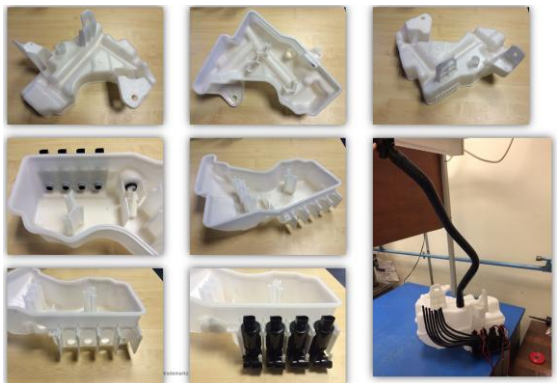


Manufacturing dwg for Tank lid & Base:-





Images of first off tool parts from supplier:-



Abstract : -
Due to the increasing amount of casualties in road accidents around the world and also due to safety awareness and economical way of transportation, there is an increasing demand for the autonomous driving cars around the world.
Now when talks are going on for complete autonomous driving cars, the real life situation like traffic problems, reliability on sensors for responding, limits the capabilities of car from being fully automated. This is where the

current emphasis is going more on semi-autonomous driving cars - which would take the control of car from drivers when the road is clear and the paths are not complicated, like on motorways.
The current project explains about the various sensors being used for one of the autonomous cars of a major European OEM and the need of an cleaning or washer system for effective functioning of these sensors and how this system was designed and how it would work in real life situation.

Amit Manjre. "Cleaning System Design For Autonomous Driving Of Car". *IOSR Journal of Engineering (IOSRJEN)*, 10(1), 2020, pp. 61-70.