Optimization of Engine Performance for better Engine Cooling in Autocross Racing

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Introduction

Autocross racing generally involves many maneuvers that put a large amount of strain on the engine. In order to rectify the heat generated and keep the oil at functioning levels, an aftermarket engine oil cooler can be installed. The purpose of this project is to test different configurations of bumpers and chassis modifications which will allow for the lowest drag, while increasing the airflow across the oil cooler.

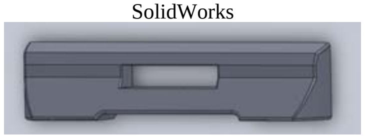
Project Description

The project uses a 914 model from previous groups to model specific bumpers in SolidWorks. In addition, the engine oil cooling system was also modeled and implemented into the vehicle assembly, to account for the flow dynamics of the cooler itself. Finally, using SolidWorks Flow Simulation, CFD analysis was performed to get drag and airflow values for each specific car design.

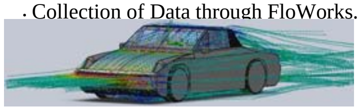
Project Objectives

- Research of engine oil cooling systems to see what others have done.

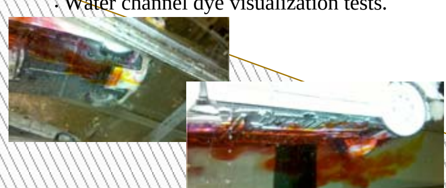
- Creation of these configurations with SolidWorks



- Collection of Data through FloWorks.



- Water channel dye visualization tests.



Engine Oil Cooling Components

The specific cooling system being looked into was a front mounted system that took in air through a hole in the front bumper and valence. Air then traveled through the oil cooler contained in a fiberglass shroud. This is where heat is exchanged from the oil to the air. Finally, air is let out through the bottom of the car through some sort of exhaust port.

Aerodynamic Theory

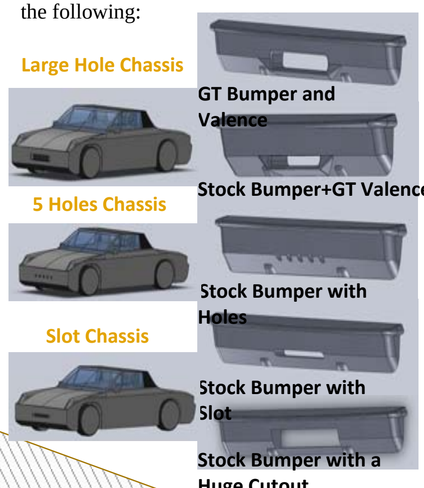
- Flow separation occurs as a result of the suction effect and pressure differentials at inlet (Bernoulli's equation)
- Chamfered edges are better than sharp ones to preserve laminar flow into oil cooling department
- Less edges relate to and cause less disturbance of the incoming airflow
- The outlet apertures should be located as far away from the front fascia as possible

Airflow from exhaust can flow back into the inlet ducts, known as recirculation

Limited application in our case because of restricted variability due to oil shroud configuration

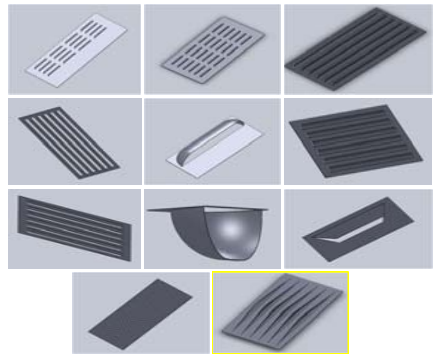
Configuration Combinations

Simulation assemblies were combinations of the following:



Exhaust Design

Exhaust ports were designed with protection from loose rocks and gravel in mind, while keeping interference with airflow to a minimum. The best design is a number of angled lances.

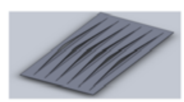


Flow Simulation Results (Exhaust)

The three best exhaust configurations and their data affecting an older model of the GT bumper is shown below. The exhausts are a tall louver, six 45 degree lances, and a metal sheet with 16 smaller louvers.

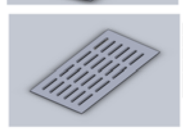
Louv er tall

Goal Name	Unit	Value
Drag Force on Car	[N]	920.7426
Pressure at Front of Car	[Pa]	102581.2
Pressure at Bottom of Car	[Pa]	100983.4
Pressure Differential	[Pa]	1597.778
Pressure/Drag Force		1.735314



Lance45

Goal Name	Unit	Value
Drag Force on Car	[N]	906.0348
Pressure at Front of Car	[Pa]	102594.3
Pressure at Bottom of Car	[Pa]	101137.4
Pressure Differential	[Pa]	1456.891
Pressure/Drag Force		1.607985



louv er full

Goal Name	Unit	Value
Drag Force on Car	[N]	905.154
Pressure at Front of Car	[Pa]	102640.8
Pressure at Bottom of Car	[Pa]	101235.3
Pressure Differential	[Pa]	1405.496
Pressure/Drag Force		1.55277

Flow Simulation Results (Car)

All configurations were run with both a large hole for the exhaust, as well as the best exhaust design (45 degree lances). The drag force and coefficient of drag of the vehicle, the pressure differential between the front of the oil cooler and the bottom of the car, and the volumetric flow rate of air through the oil cooler are the relevant data. A table with data at 70 mph follows:

70 MPH							
#	Bumper	Body	Exhaust	cD	Drag Force(N)	Δ Pressure	Air Flow (m3/sec)
Stock Bumper							
1	Holes	Holes	Hole	0.34	299	-107	0.035
2	Slot	Slot	Hole	0.34	301	-42	0.045
3	Huge Hole	Huge Hole	Hole	0.35	308	340	0.064
4	Holes	Holes	Lance	0.34	303	-152	0.035
5	Slot	Slot	Lance	0.34	301	-51	0.041
6	Huge Hole	Huge Hole	Lance	0.36	321	328	0.094
7	GT	Holes	Hole	0.35	309	-105	0.036
8	GT	Holes	Lance	0.36	315	-145	0.032
GT Bumper				cD	Drag Force(N)	Δ Pressure	Air Flow (m3/sec)
9	GT	Holes	Hole	0.35	309	318	0.039
10	GT	Slot	Hole	0.35	309	365	0.042
11	GT	Slot (GT)	Hole	0.35	307	414	0.086
12	GT	Huge Hole	Hole	0.35	307	412	0.089
13	GT	Holes	Lance	0.36	319	283	0.034
14	GT	Slot	Lance	0.36	318	320	0.038
15	GT	Slot (GT)	Lance	0.36	319	380	0.064
16	GT	Huge Hole	Lance	0.36	318	375	0.066
Sheridan Bumper (Air Dam)				cD	Drag Force(N)	Δ Pressure	Air Flow (m3/sec)
17	Sherida	Hole	Hole	0.4	354	489	0.098
18	Sherida	Hole	Lance 45	0.41	366	481	0.092

Discussion

From the gathered data, the configurations were judged based on their coefficient of drag, how their shape influenced the air flow through the oil cooler, and the pressure differential between the front of the oil cooler and the bottom of the car. In addition, the cross sectional plots and animations were also considered to make sure the flow did not stagnate in the duct.

The drag force did not change with differing chassis configurations, indicating that the drag force was dependent on the bumper shape.

The Sheridan bumper, which was tailored to increase volume flow through the duct while increasing drag, did exactly as expected. However, the drag induced by its shape is significantly larger, increasing the drag coefficient to .41, while the increase in volume flow was not as substantial.

Negative pressure gradients occurred when the stock bumper was combined with small openings such as holes or a small slot. This indicates that these holes do not allow enough airflow through the oil cooler system, resulting in large stagnation points inside the duct. Stagnant air continues to circulate through the shroud, and more heat is absorbed from the oil cooler. This implies that small openings in the bumper and chassis for the oil cooling duct are insufficient.