Exhaust System

Gurshan Deol
Maharshi Patel

Today’s talk

- Background
- Engineering Methodology
- Obstacles and Challenges
- Integration
- Recommendations/Future Plans
- Lesson Learnt

Background

- Needs Statement
- Problem Statement
- Objective
- Constraints
- Criteria

Needs Identification

In a hybrid powertrain an exhaust system is an integral part of the car. This is the only system that allows the car to omit the emission and safely lets the dangerous gases into the environment

Problem Statement

Designing the car's exhaust is very challenging due to the nature of the competition. Handling emission and routing the exhaust has proven to be a difficult task in the previous year

Objective

To come up with a robust, efficient, and performance driven exhaust system design.

The exhaust system will be designed to route between other components to prevent interference

How does it fit in our team

Controlling emission is a critical part of the competition that the team needs address as their primary goal when designing.

Constraints & Criteria

- Cost of the Solution
  - Cost should be less than last years
  - Low manufacturing complexity
- Quality of design
  - Physically reliable and durable
  - Robust performance
  - Should be lighter than last years
  - Fits within the design volume designated

Requirements

- Noise Regulation
  - Must be equipped with a muffler in order to reduce noise to acceptable audible levels
- Exhaust Leaks
  - No major exhaust leaks should be identifiable which can affect the results of the E&EC event
- Exhaust Routing & Isolation
  - minimum clearance of 51mm (2 inches) must be considered near sensitive components (battery packs, fuel lines, etc)
  - must not pass through the passenger/luggage or battery enclosure
- Exhaust Tip
  - Tip of the exhaust system must be a straight pipe to allow for the clamping of a rubber boot

Engineering Methodology

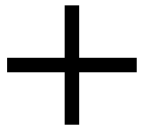
- Powertrain Selection
- Design Process
- Decision Matrix
- New Implementation
- Design Validation

Powertrain to Design for #1

Engine	
Type	2.0L I-4
Fuel	E10
Displacement	1.998 L
Compression Ratio	9.5:1
Peak Power	191kW @ 5500 RPM
Peak Torque	400Nm @ 4000RPM
Maximum Engine Speed	7000 RPM
Vehicle Orientation	Transverse

Transmission	
Type	M3H (9T50)
Configuration	Transverse
Number of Gears	9
Accumulator [Y/N]	Y
ETRS [Y/N]	Y

2.0L TURBO LTG WITH M3H GF9, and 2 other variants M3E & M3D



Electric Motor/s

Assumed Values

Power = 191 kW

Torque = 400 Nm

Powertrain to Design for #2

Engine	
Type	2.5L I-4
Fuel	E10
Displacement	2.457 L
Compression Ratio	11.3:1
Peak Power	148kW @ 6400 RPM
Peak Torque	255Nm @ 4400RPM
Maximum Engine Speed	6850 RPM
Vehicle Orientation	Transverse

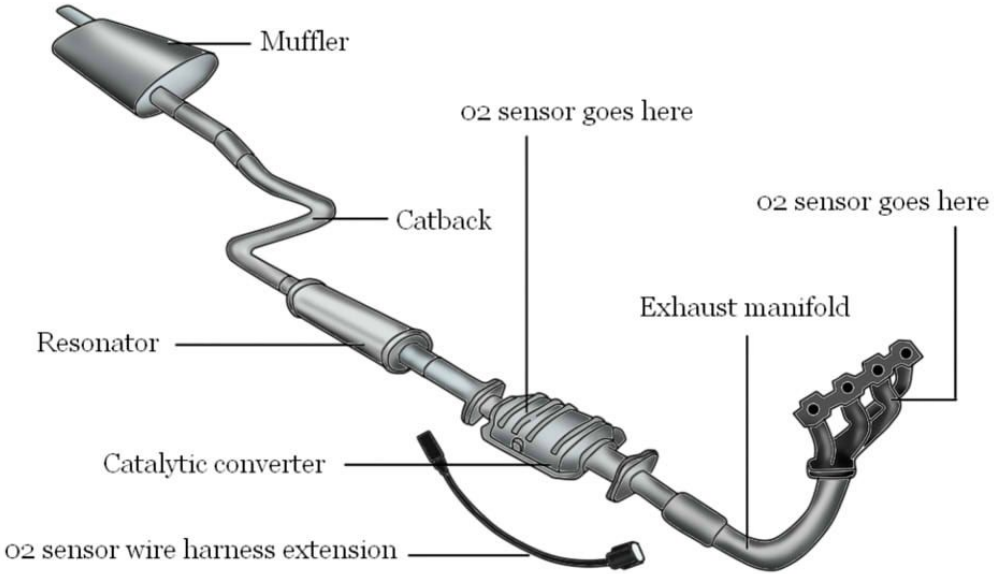
Transmission	
Type	M3D (9T50)
Configuration	Transverse
Number of Gears	9
Accumulator [Y/N]	Y
ETRS [Y/N]	N

2.5L Naturally Aspirated LCV WITH M3D GF9

+ Electric Motor/s →

Assumed Values
Power = 148 kW
Torque = 255 Nm

Exhaust System - Components



Exhaust System - Areas of Improvement

Typically exhaust systems have 2 major areas where improvements can be made to maximize engine power and efficiency

-Minimization of back pressure

-Maximization of heat-shielding

Exhaust System - Back Pressure

Various factors influence the back pressure in the exhaust system such as

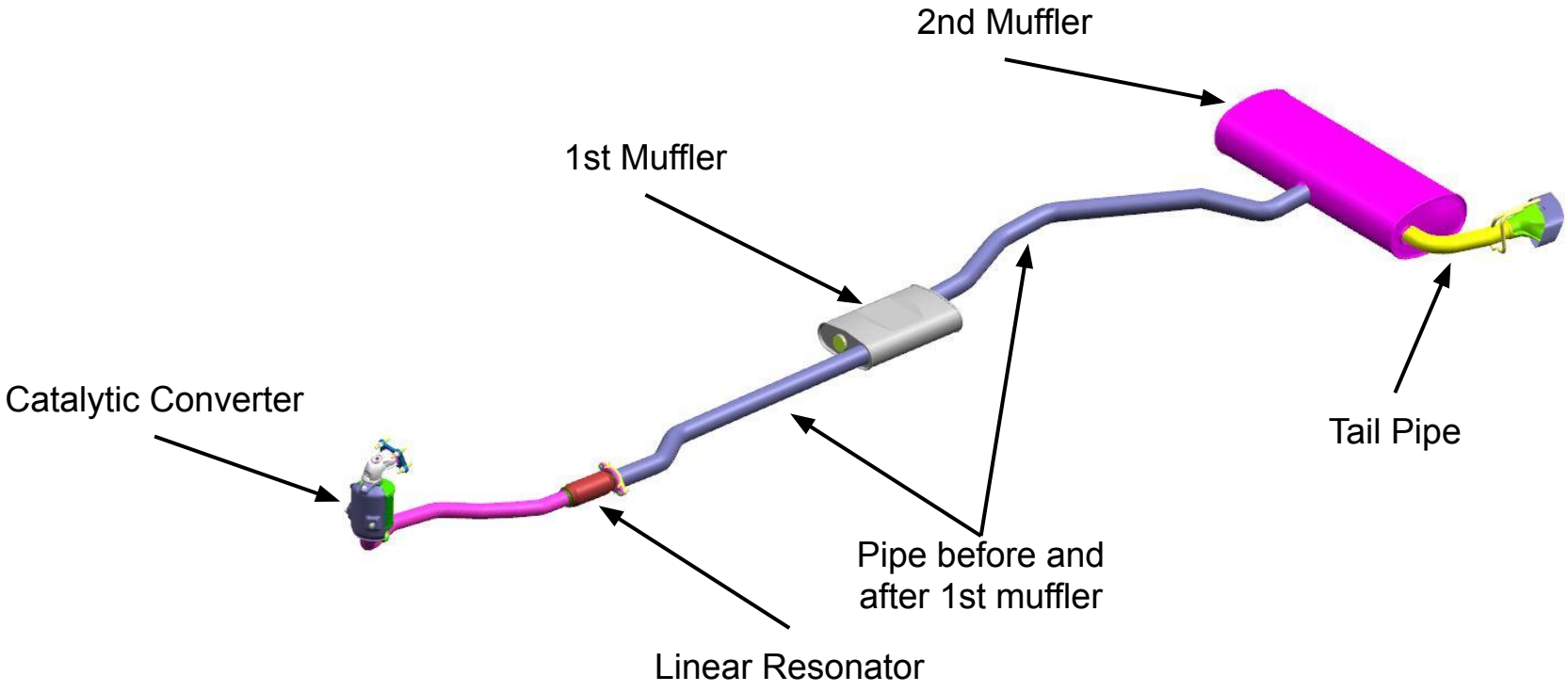
- Overall pipe length
- Change in pipe diameter
- Catalytic convertor pressure drop
- Muffler & Resonator pressure drop
- Bends in the routing

Exhaust System - Heat Loss

Heating shielding is key in the exhaust systems for a variety of reasons

- Reduces heat spreading into engine compartment
- Higher heat retention in exhaust gases
- Catalytic convertor heats up much quicker

Proposed Solution - 2.0L Turbo

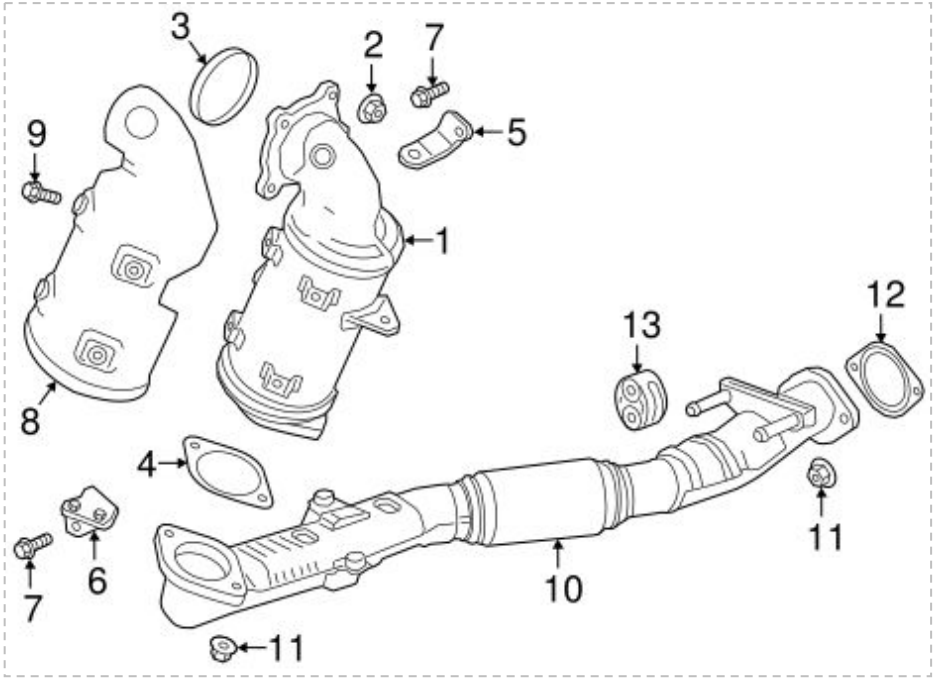


Catalytic Converter

Part No: 12666605

Name: Catalytic Converter

Price: $ 550.58 CAD

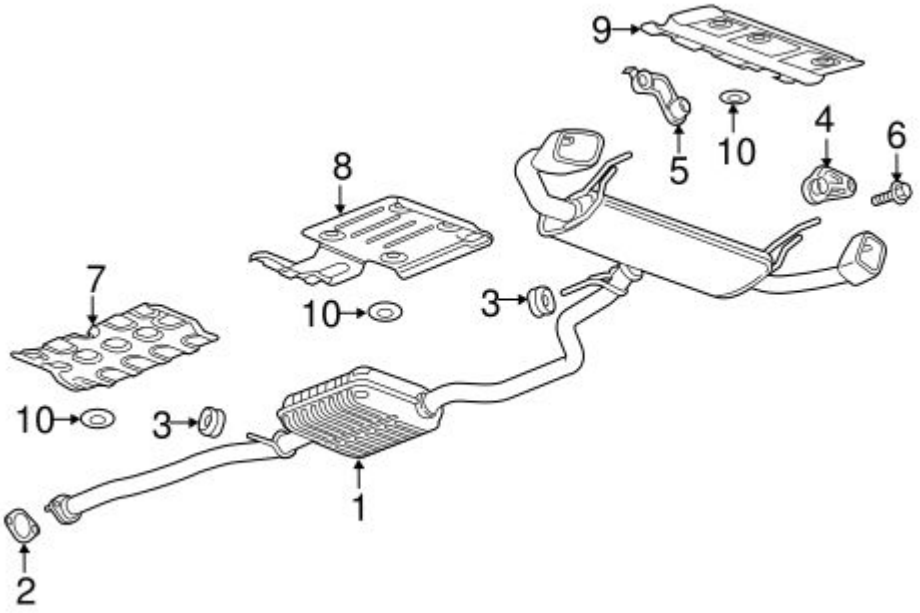


2nd Cat. converter and muffler

Part No: 84364855

Name: Muffler & Pipe

Price: $ 495.92 - $ 518.37



Estimated System Cost Breakdown

Item	Description	Reason	Cost
Aluminized Steel tubing	Straight tubing, raw material	Use to connect exhaust components	~$3/in
Stock exhaust components	Stock components for either 2.0L or 2.5L engine	Optimized exhaust components designed for the vehicle	~$500-700
Pipe bending	Angle bends, flattening sections, etc	Necessary for routing the steel tubing around different sub-modules	Unknown
Exhaust mounts	Hook mounts that attach to exhaust pipe	Necessary for mounting the exhaust system	~$20
Welding consumables	Flux, shielding gas, material	Necessary for joining tubing sections	Unknown
Heat shielding wrap	Fiberglass pipe wrapping	Insulates and contains exhaust pipe heat	$30-40
Labour	Welding, pipe bending,	May need to pay for these	Unknown

Decision Matrix

Criteria	Weight	Single Plate	**Multi Plate**
Cost	7	7	**6**
Integration	7	7	**5**
Reliability and Durable	9	6	**8**
Performance	8	6	**8**
Prior Knowledge	5	5	**5**
Max Points	*31*	27	**28**

1 = Lowest Priority
10 = Highest Priority

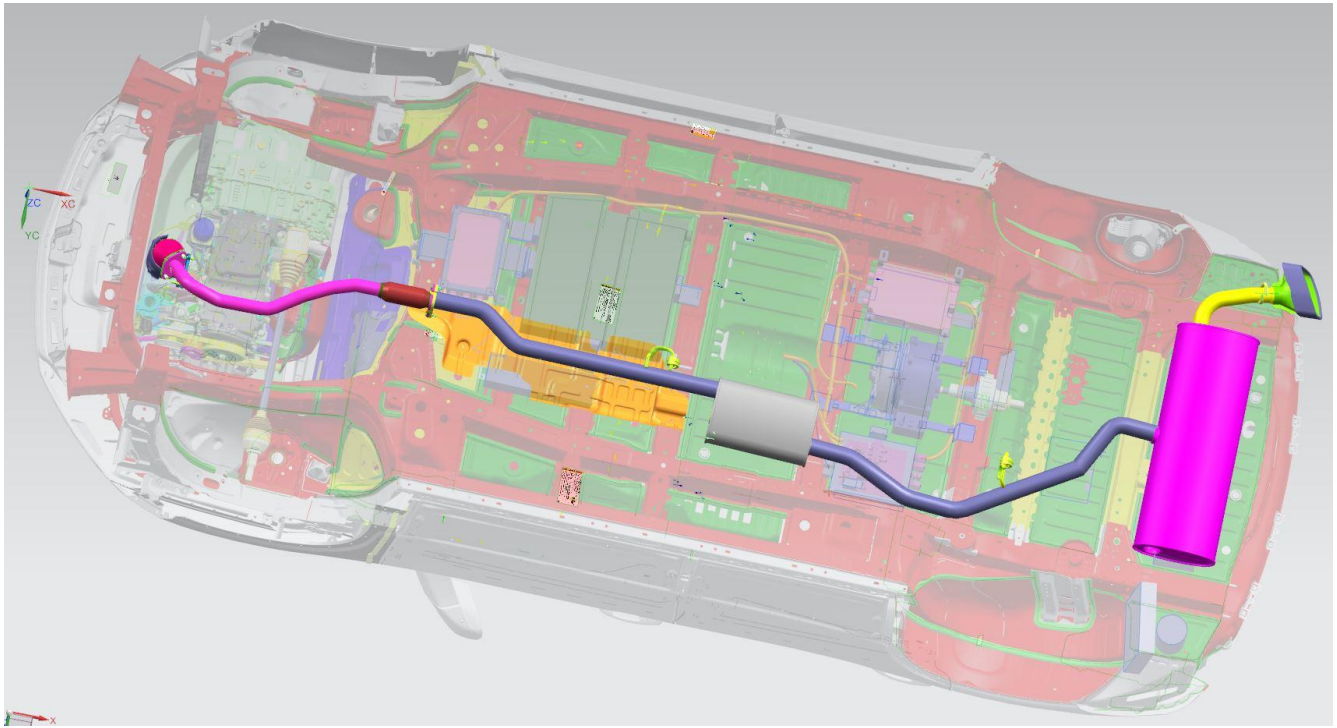
Design Validation

- Frequency response analysis for NVH, as well as, CFD for calculating pressure drop/back pressure along the pipe
- Buy the part and test it in practice
- Smoke/soap bubble test of the completed exhaust system to find potential leaks

Obstacle and Challenges

- Challenge is to design the exhaust system while doing exhaustive research on components is tremendously hard
- To overcome the challenge assumptions were made and geometry changes were assumed as well as other similar models system were taken to design the parts

Integration



Recommendation and Future Plan

- Powertrain finalization in order to confirm the exhaust system design
- Prepare DOE’s and simulation models to simulate the response of the system
- Conduct vibration and CFD analysis to benchmark the performance of the system
- Conducting leak testing

Timeline

	Jan 1-14	Jan 14-31	Feb 1-14	Feb 14-28	Mar 1-14	Mar 14-31	April 1-14
Task 1	Initial Research						
Task 2		Setup & Practice CAD					
Task 3			Investigate components, compile research results				
Task 4				Create CAD of placeholder exhaust system			
Task 5						Report writing	

Lesson Learnt

- Designing a single part takes a lot of attention to detail
- Make sure the things you plan can or are actually attainable with respect to time

Thank You!
Questions?