Work Portfolio

Visual-Aid for Resume

Isaac Haynes

- Mechanical Engineering Student at the California State Polytechnic University, Pomona
- Graduation Date: December 2024

DIVERGENT

Test Engineering Intern – Summer 2024

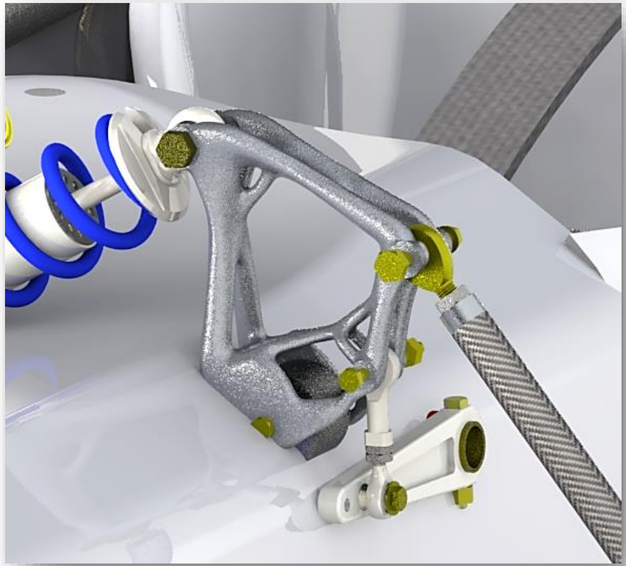
BRONCO MOTORSPORTS
SINCE '88

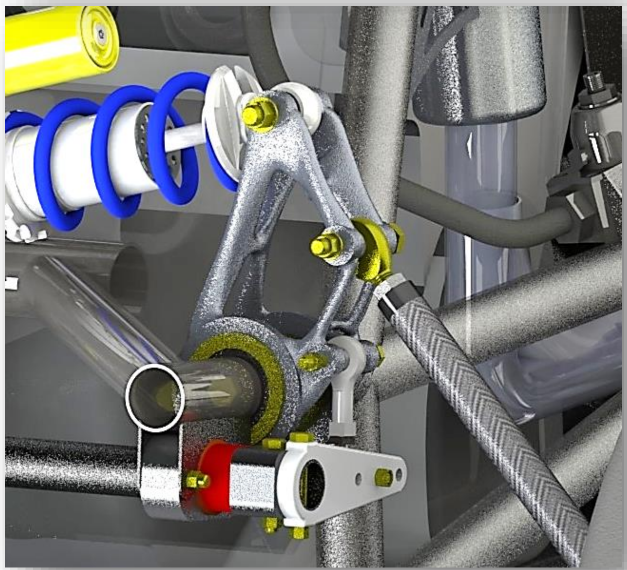
Cal Poly Pomona Formula SAE

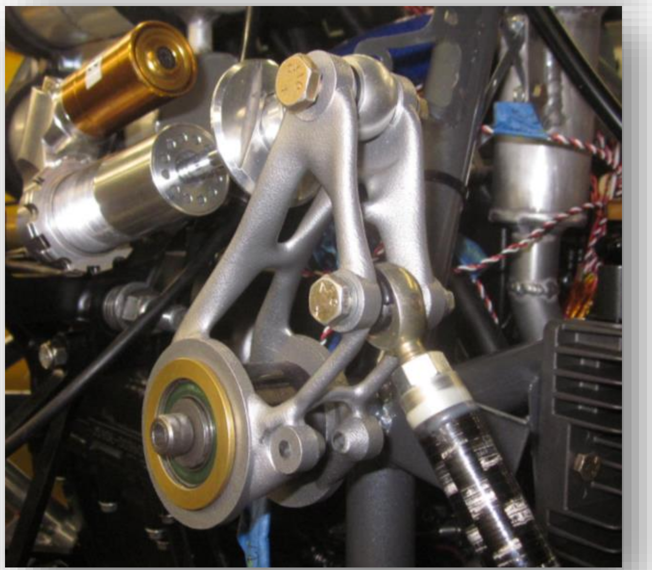
✓ Previously involved with the past 4 full-year design cycles (2021-2024)

International Competition at Formula Student Austria & Formula Student Hungary 2024

Formula SAE – Generative Design Rockers







Specs

Motion Ratio - 1.20 F, 1.00 R

Material: AlSi10Mg – Heat Treated to Yield at 21 ksi

Fronts

Weight: 0.328 lbf
Stiffness: 33x gained
FOS: 3.6

Rears

Weight: 0.257 lbf
Stiffness: 8x gained
FOS: 2.7

Designed to attain desired damper velocities of our underdamped mass-spring-damper system whilst reducing sprung mass

These structural components were designed using an extensive application of **on-track lin-pot data** from 2023 Michigan Endurance and Autodesk Fusion360 **Generative Design** Extension. Static, dynamic, fatigue, and non-destructive testing has occurred to properly validate these parametrically-optimized geometries as a direct **weight reducing and stiffness increasing** feature of our racecar suspension.

Final Rocker Forces (lbf)	Front	Rear	Force Logic
Push-rod	425.82	480.18	*Max F_z seen*
Damper	371.76	474.08	*F=vc+kx*
ARB	86.34	122.64	*F=kx*

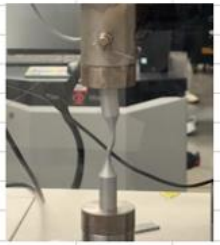
23-24 Max Loading Cases

Scenario	Lateral	Longitudinal	Vertical
Vertical Bump	0	0	3
Acceleration	0	1.2	1
Braking	0	-1.5	1
Cornering	2.4	0	1
Cornering + Acceleration	2	0.8	1
Cornering + Acceleration + Bump	0.7	0.5	1.2

*all values in Gs

Formula SAE – Generative Design Rockers – *MAT TEST DATA*

X-Sec Area (in^2)	0.02984963
Max force @yield (lbf)	632.117
Yield Strength (ksi)	21.177
Ultimate Strength (ksi)	43.032
Stiffness (lbf/in)	
Young's Modulus (ksi)	
Original Length (in)	
Disp @ Yield (in)	0.0155



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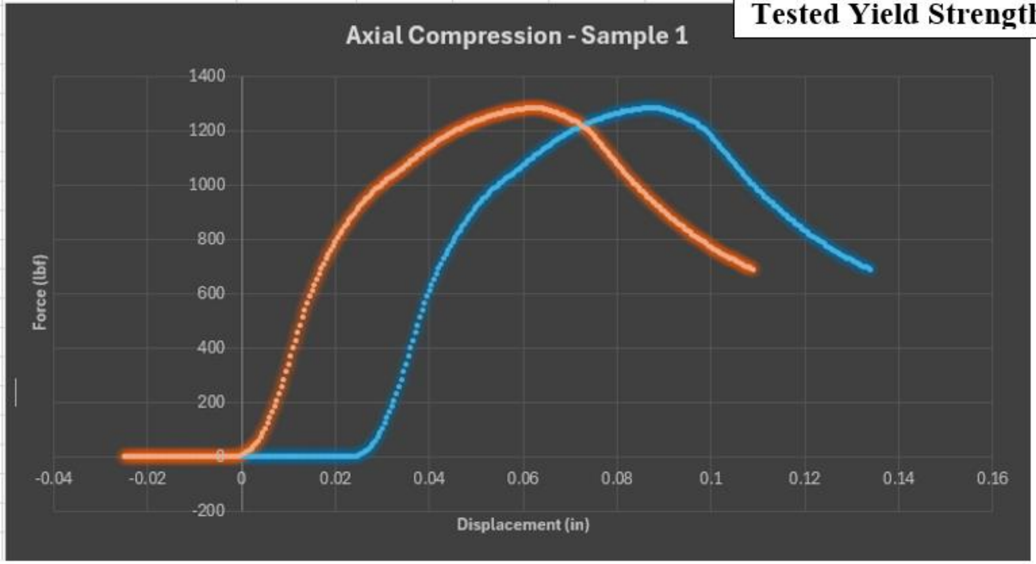
Rocker Material Testing – AlSi10Mg

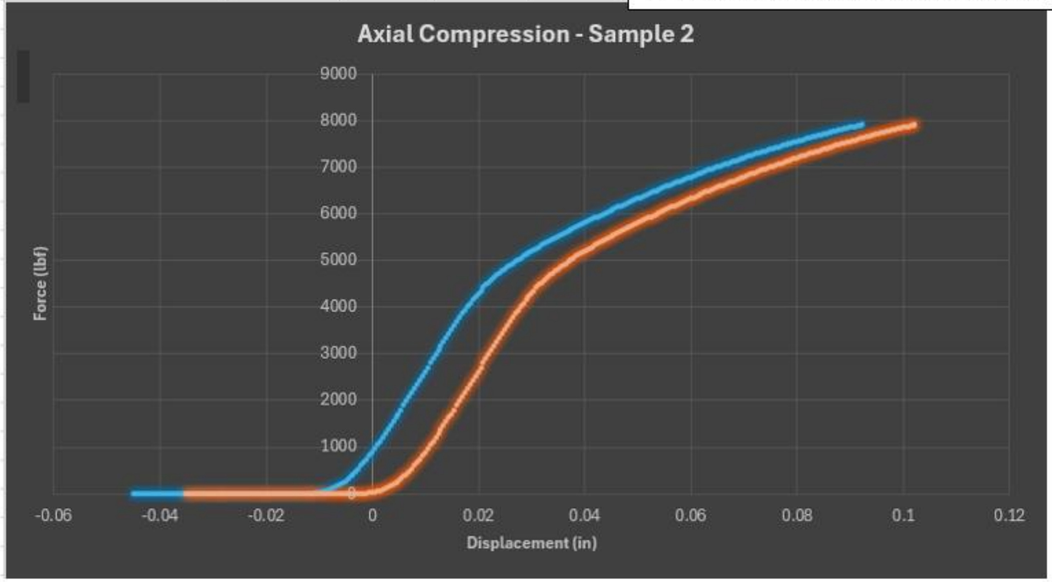
Rated Yield Strength: 28ksi

Tested Yield Strength: 21ksi



X-Sec Area (in^2)	0.1846516
Max force @yield (lbf)	7904.929
Yield Strength (ksi)	21.328
Ultimate Strength (ksi)	42.810
Stiffness (lbf/in)	
Young's Modulus (ksi)	
Original Length (in)	
Disp @ Yield (in)	0.0274

*3D-printed rocker testing can really only be achieved indirectly through load cells or strain gauges on the rocker or pushrod itself. This may be in the works over the summer, but I'd highly recommend having this properly implemented onto the rockers for next year. Otherwise, we have little to no true validation that any of our hand calculations or simulations are reasonably correct.



Formula SAE – Carbon Fiber Pushrods

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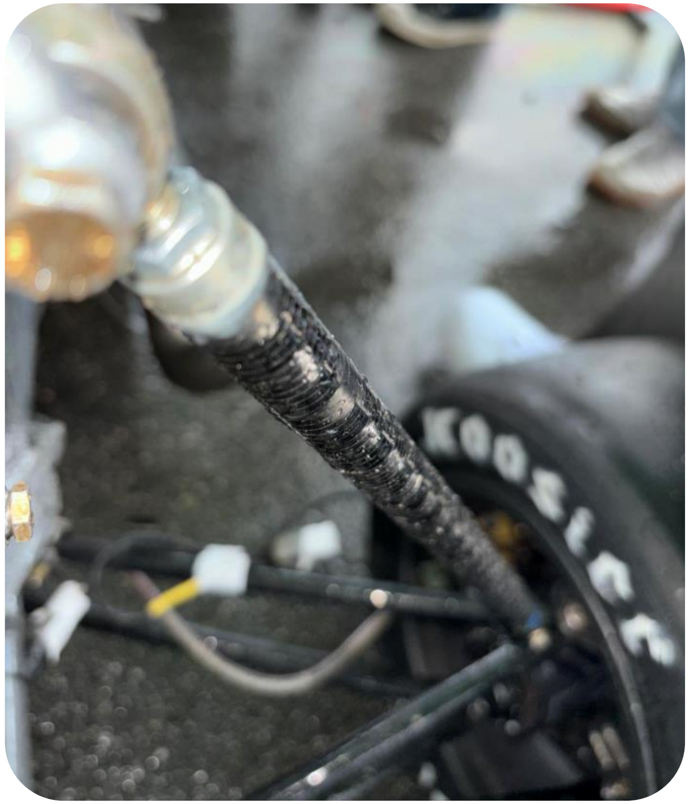
Specs

- Roll-wrapped carbon fiber tubing w/ 7075 Aluminum Inserts into 3/8-24 Mil spec rod-ends
- Extensively tested in tension, compression, bending, and fatigue
- 0.628” OD, 0.500” ID
- Henkel Loctite E-120HP Hysol epoxy resin
- 0.008” bond gap, 1” bond length



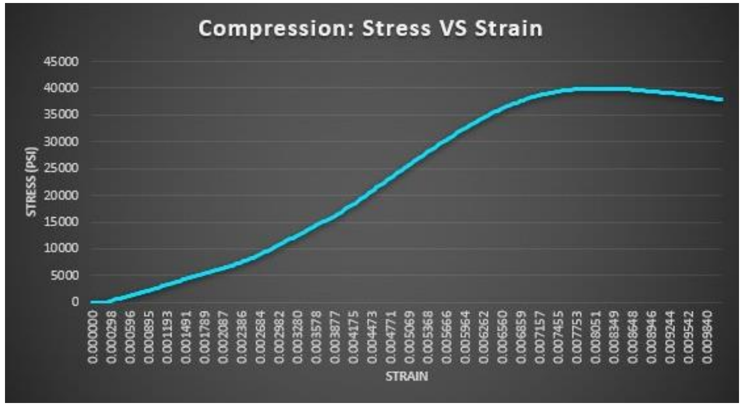
Rear Toe-Link Bond failure on CF-Resin interface during on-track testing. (Sudden rupture during forward accel)

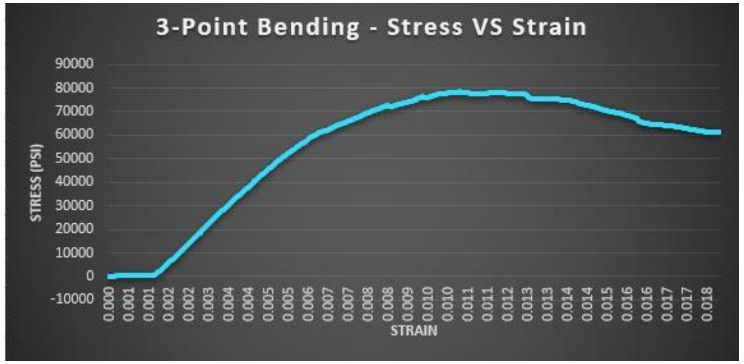
TEST DATA

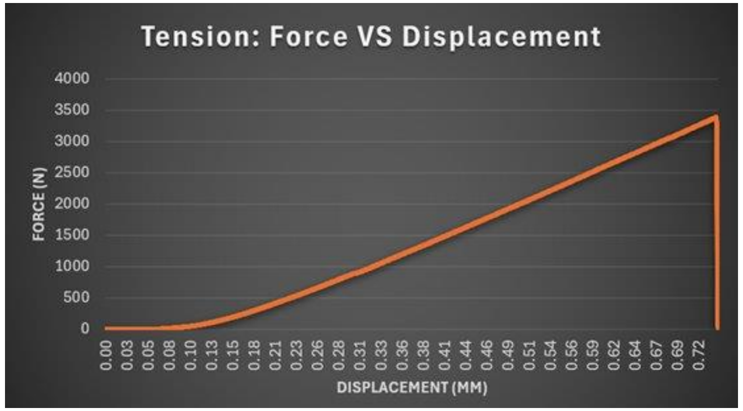
$$\sigma_{max,c} = 37\ ksi\ @3529lbf$$

$$\sigma_{max,b} = 78\ ksi\ @385lbf$$

$$F_{max,t} = 760.160\ lbf$$







Formula SAE – Cooling System

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Design

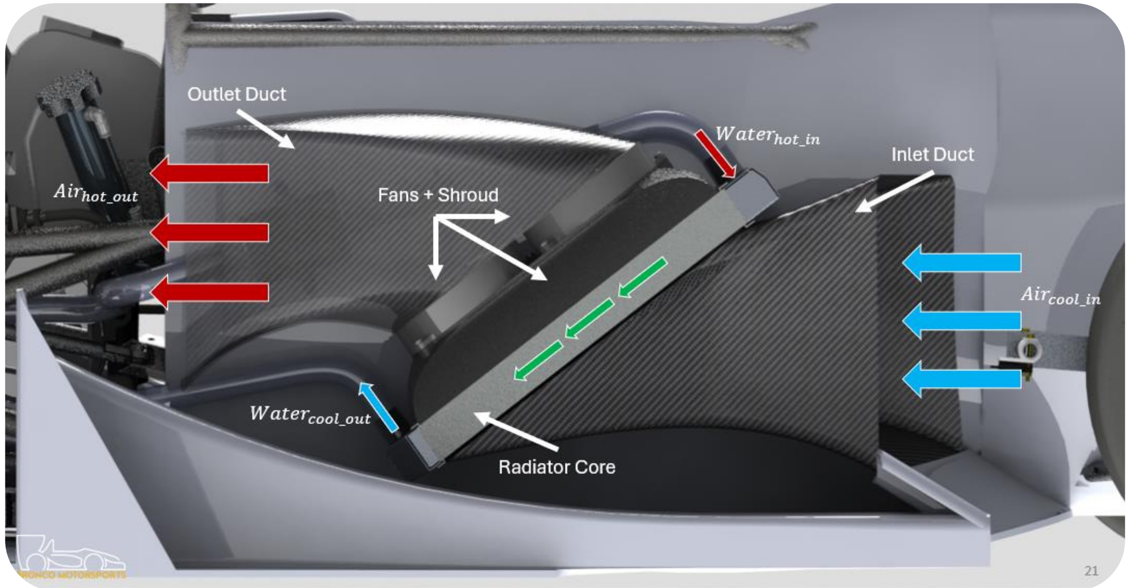
- *<u>Reject sufficient engine Qdot, Increase mass flow of air and water whilst reducing system weight</u>*
- Engine oil is liquid cooled via Laminova HX
- Carbon fiber shroud (3-ply)
- Single radiator, single pass, 8”x14”x1.5”
- SPAL 2x 5.2” Fans (Brushed, 350 CFM each)
- External Electric Water Pump

Build

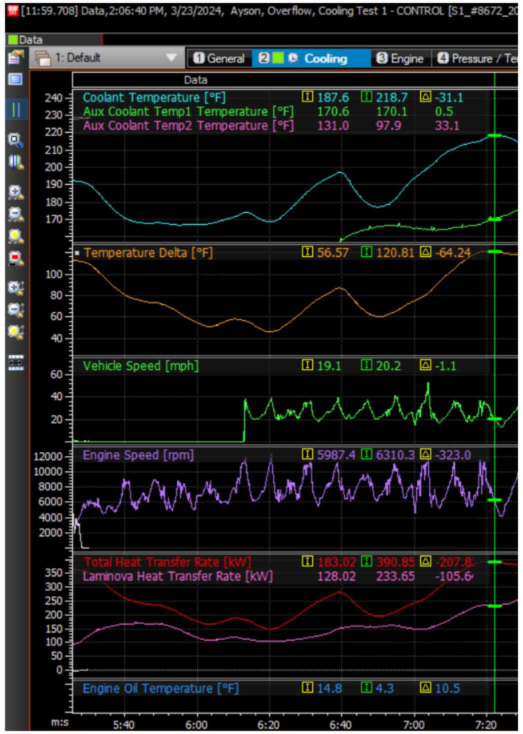
- Swirl Pot & Radiator end-tanks fabricated in-house
- **Greatly simplified mounting**
  - By using two pin connections, system is now extremely rigid, and removal of radiator is done with just 1 nut and 1 bolt.
- Carbon Fiber shroud created with a wet lay-up resin process
- Custom CNC-lathed Venturi Meter

Testing & Validation

- Heat Transfer Rate vs Mass Flow Rate of Air and Water
- How close are we to our targets?
- How reliable is the data?

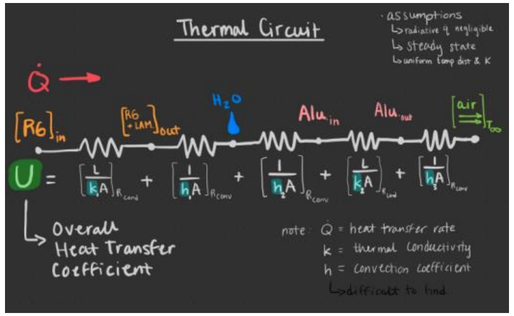


37% weight reduction with 22% greater thermal efficiency with EWP, 2 fans, and fully-ducted inlet & outlet (VS 2023 Specs)

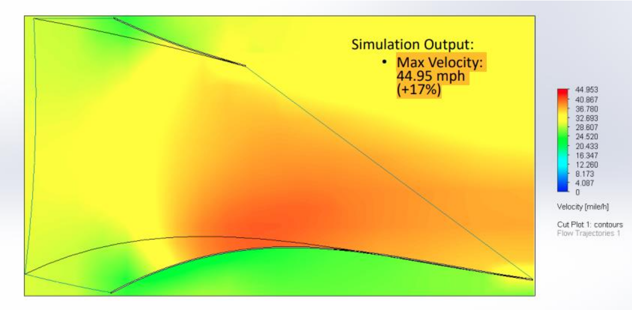


On-track data acquisition and thermal performance analysis via MoTeC i2Pro

Convection Coefficients derived through thermal circuit analysis



Inlet Duct Flow at 30mph



Venturi meter to track water mass flow

Formula SAE – Cooling System – *On-track Mass Flow Rate*

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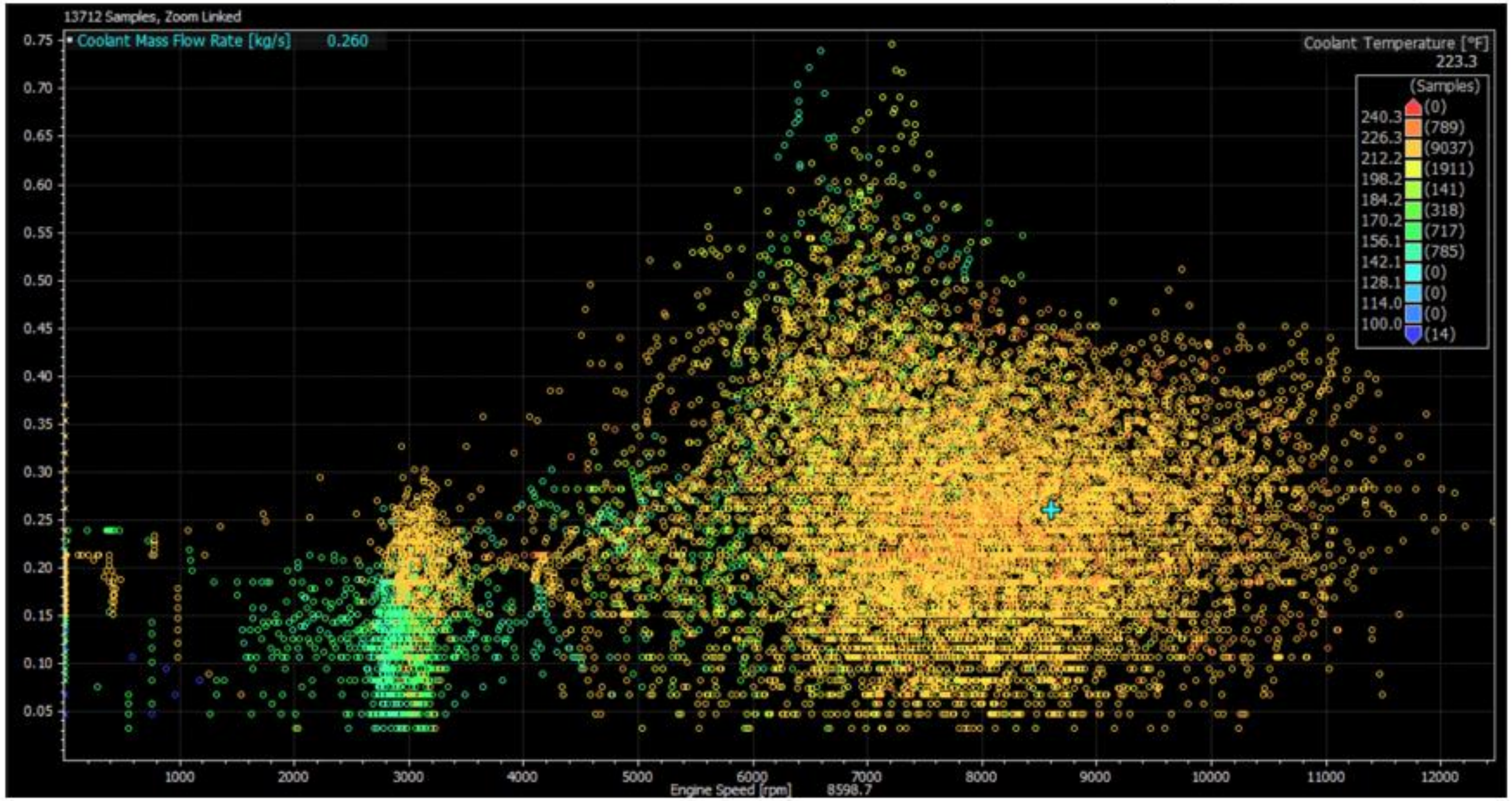
Notice how mass flow rate peaks out at 7000RPM. You would think it'd be linear with engine RPM, but it is not. The pumps reach a best efficiency point at 7000RPM then drop off due to the system curve. It is important to note that this is with both the mechanical and electric pumps running. I'd be very curious to run the venturi meter and see how this scatter plot changes with a single steady-state electric water pump + dynamic heat input from the engine on-track

Spring Break Testing Data

$\dot{m}_{water}$



Engine RPM

Formula SAE – Intake Manifold

Specs
Material: Carbon Fiber Reinforced Nylon - 3D-Printed Plenum and Runners

Plenum
- 3000cc volume determined via Helmholtz Resonance
- Integrated restrictor with optimized nozzle angles

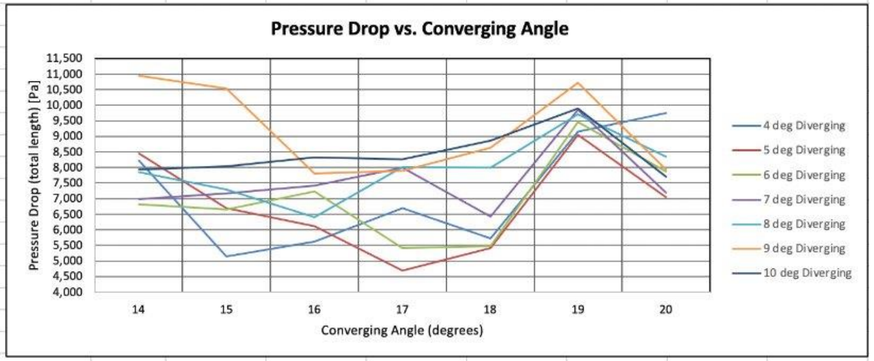
Runners
- 3.8in runner length design for optimal flow at AVG RPM on track.
- Internal bell mouths

Throttle Body
Electronically controlled via Bosch DC motor

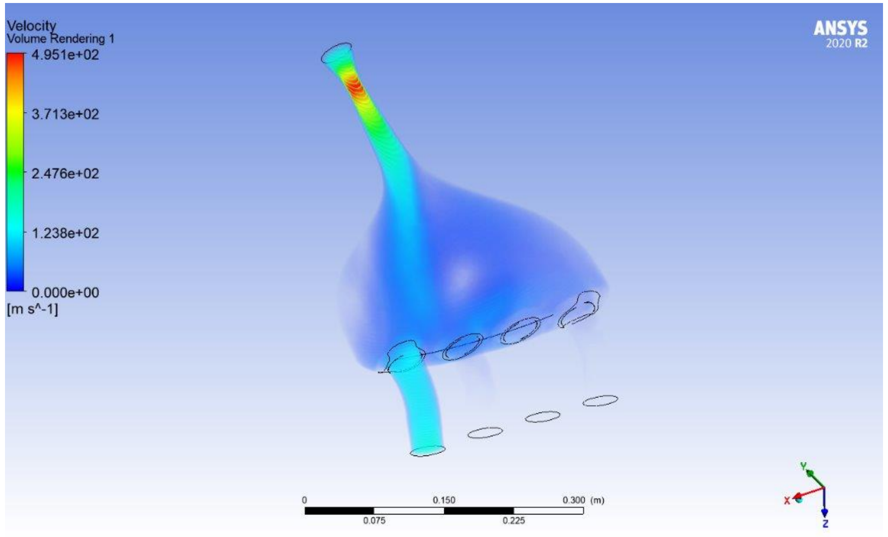
Structurally designed to flex under high-vacuum + high temperature conditions: Deceleration, Downshift Rev-matching, Launch Control

Restrictor nozzle converging/diverging angles derived at minimum pressure drop

m = 0.06793	kg/s	Pressure Differential over Length (Pa)						
Pin= 101325	Pa							
T = 300	K	Diverging Angle						
		4	5	6	7	8	9	10
Converging Angle	14	8,214	8,445	6,808	6,980	7,857	10,936	7,938
	15	5,134	6,685	6,649	7,159	7,302	10,537	8,025
	16	5,624	6,124	7,231	7,409	6,402	7,810	8,318
	17	6,697	4,690	5,419	8,003	8,011	7,890	8,256
	18	5,730	5,418	5,467	6,418	7,987	8,642	8,852
	19	9,154	9,043	9,450	9,849	9,714	10,718	9,897
	20	9,741	7,038	7,864	7,191	8,336	7,938	7,711

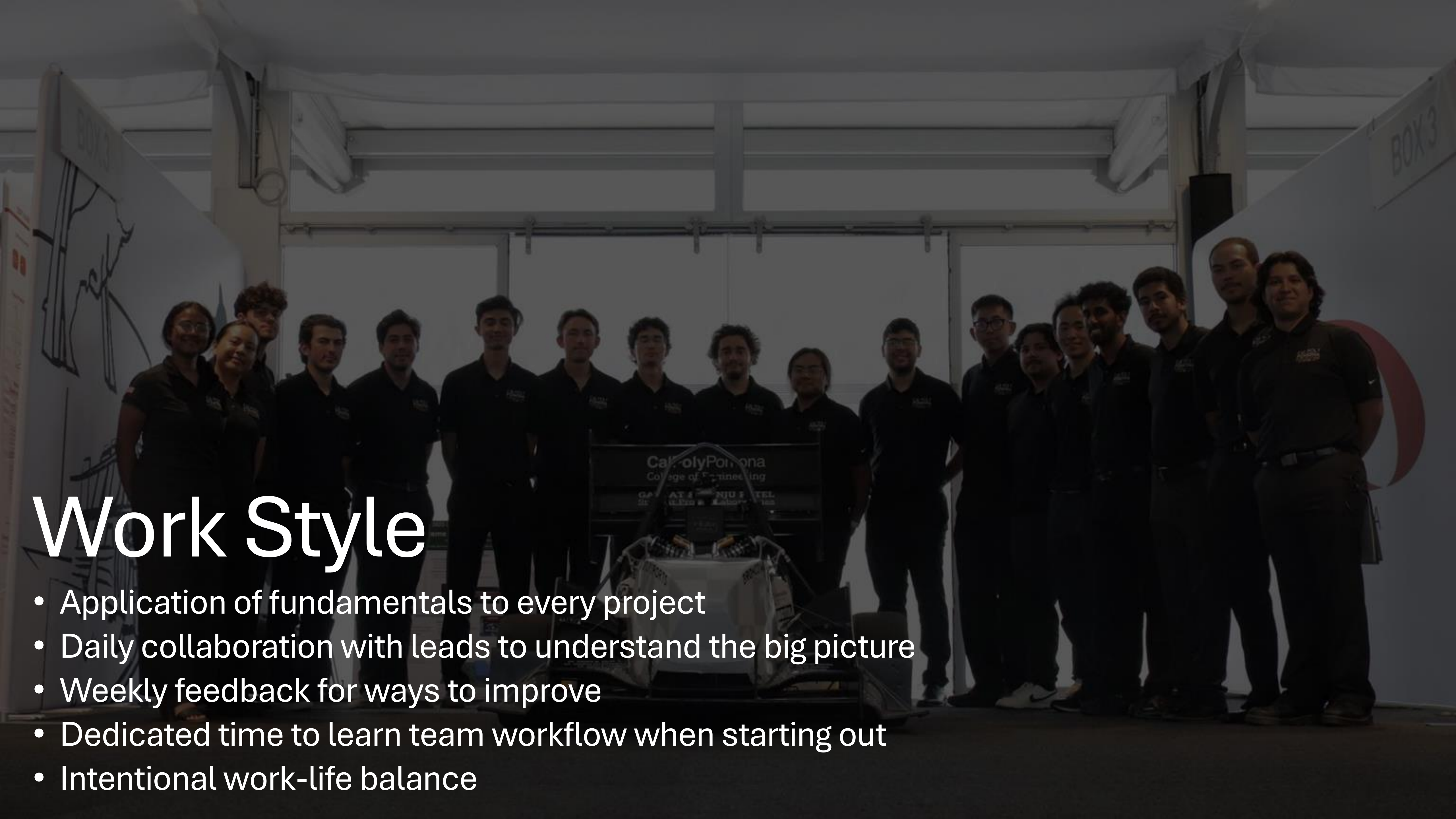


ANSYS Fluent CFD at avg track RPM: V=mach1.5



acco engineered systems

Project Engineering Intern – Summer 2023



Work Style

- Application of fundamentals to every project
- Daily collaboration with leads to understand the big picture
- Weekly feedback for ways to improve
- Dedicated time to learn team workflow when starting out
- Intentional work-life balance