

TSAE Auto Challenge 2009 - Student Formula

1. Engine Tune-up and Muffler Design
2. Design, Fabrication and Quality Checks on Electric and Electrical Equipment Component



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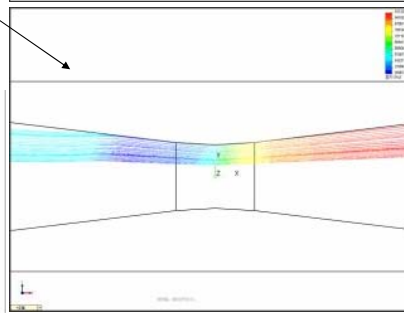
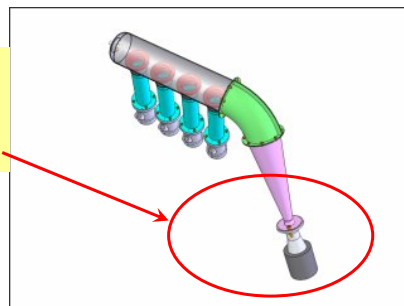
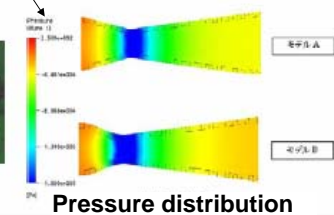
Restrictor Design

Student Formula must put the $\phi 20$ restrictor between throttle valve and intake port.

- Textbook recommend less than 15deg.
- Best Inducer and Diffuser Angle decided to be 7deg by one of Japanese Univ. team.
- Other team's simulation



restrictor



Intake Manifold Design

- Recommend for use of **the original intake manifold** of the engine.
- Eddies will produce the constriction flow which reduce amount of flow.
- CFD (Computational Fluid Dynamics) simulation is popular for unique design.
- Unique design tends to focused to mid range engine power between 5000 to 10000 rpm to drive faster on the curvy formula course.

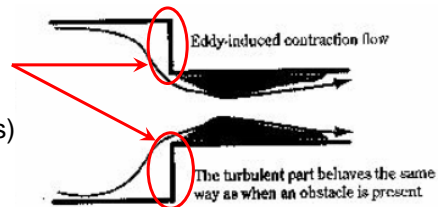
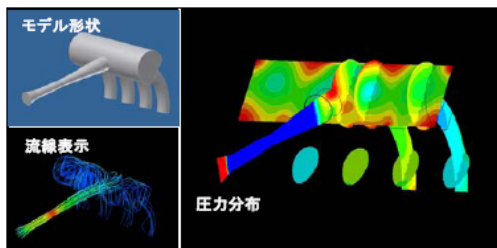
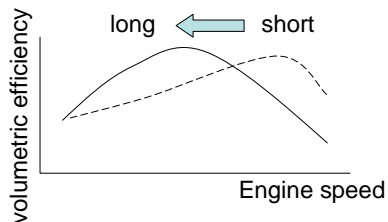


Fig. 10-1 Concept Diagram of Pressure Loss at Edges



Intake Manifold Design

- Huge volume will result in slow response.

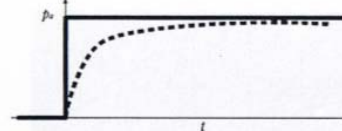
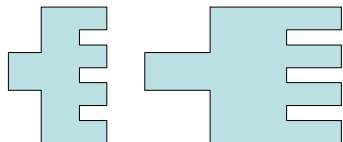
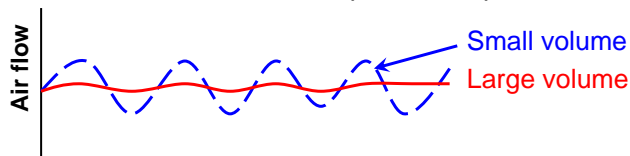
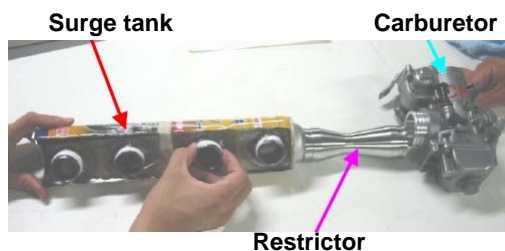


Fig. 10-13 Response to Intake Throttle

- Too small volume will cause a problem of pulsation flow.



Example of the surge tank design for carburetor



Intake and Exhaust Manifold Design

- Distribution of uniform air amount is very important.

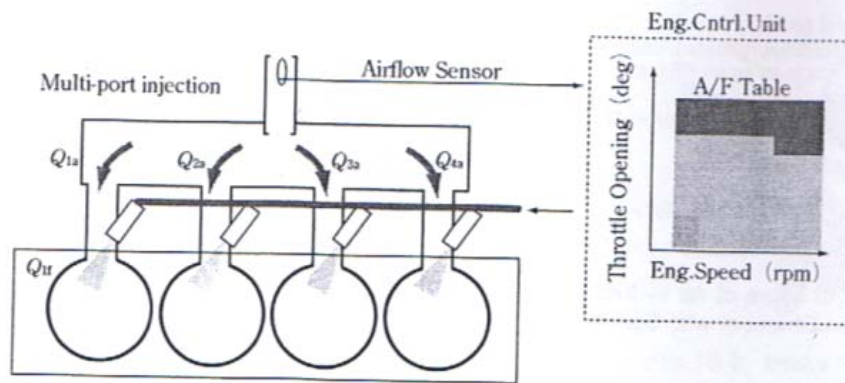


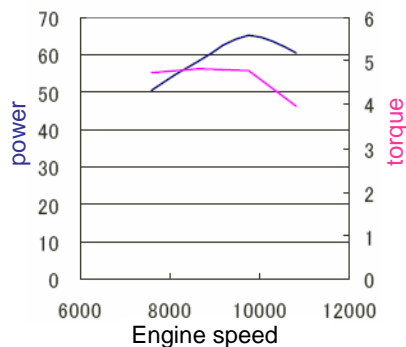
Fig. 10-8 Measurement of Intake Air Flow at One Location and Distribution of Uniform Air Amount for Uniform Fuel Injection

Exhaust Manifold Design

- Recommend for use of [the original exhaust manifold](#) of the engine.
- Unique design tends to focused to maximum engine power with lower engine speed.

➤ *Example of Japanese team result modifying intake and exhaust manifold*

original	64[PS]/12000[rpm]	4.3[kg·m]/9000[rpm]
modified	65[PS]/9700[rpm]	4.9[kg·m]/8600[rpm]

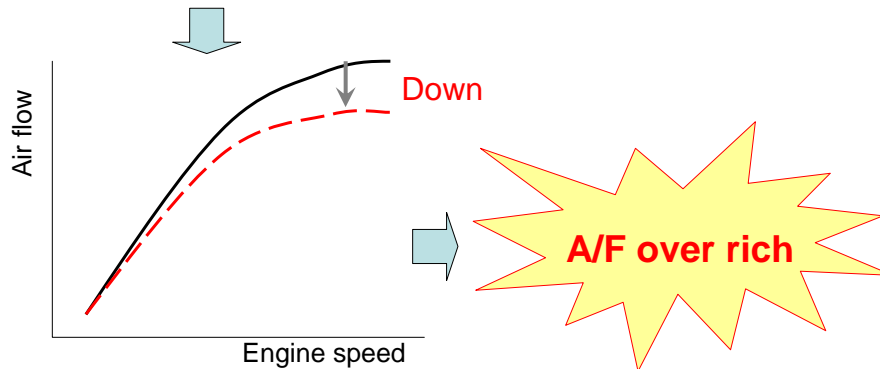


4-2-1 ex-mani

Engine Tune-up : Effect of the restrictor



- Air flow will be reduced for high flow rate condition (high engine speed and full throttle).



A/F and power, economy

- **Power best A/F** is rich. (approximately 13.0)
- **Fuel economy best A/F** is lean. (16~18)
- **Theoretical A/F (stoichiometry)** is 14.6~14.8.
- A/F will be set **rich** with full throttle driving condition to get power and cooling effect to prevent melting engine parts.

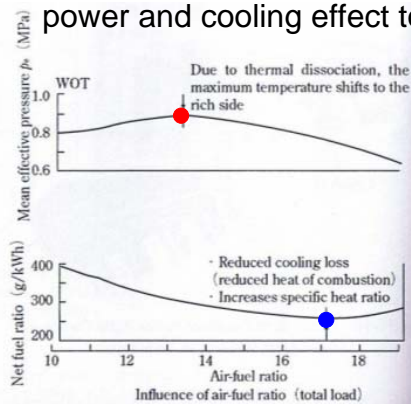


Fig. 10-14 Output of Air-Fuel Ratio and its Influence on Fuel Efficiency

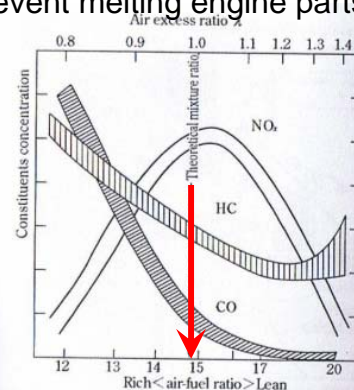


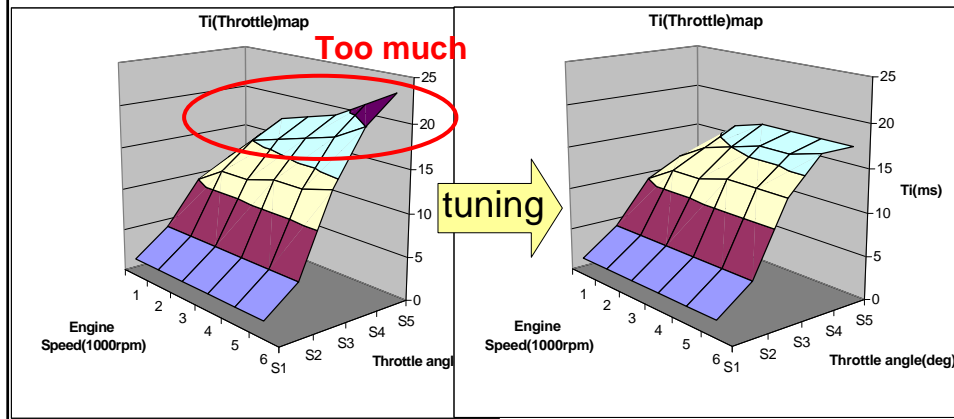
Fig. 10-15 Influence of Air-Fuel Ratio on Concentration of Harmful Constituents Emitted

Adjusting fuel injection amount

You must adjust injection amount according to decreased intake air amount.

Original fuel injection map

Adjusted fuel injection map



Analysis of Engine Control System

You must analyze the engine control system which you will use for race car.

- Check the service manual.
- Guess how to decide Ti.

•How to measure air flow

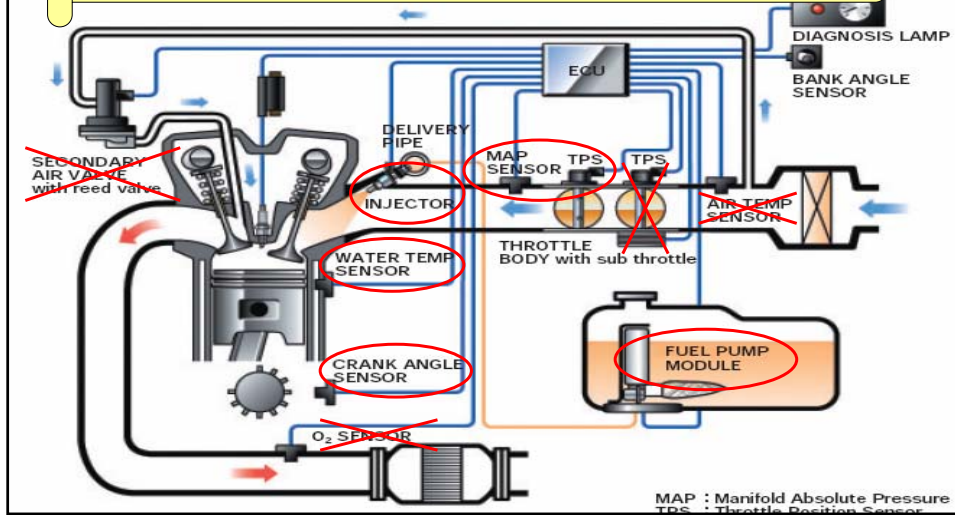
- Air flow sensor
- MAP sensor (Manifold Absolute Pressure)
- TPS (Throttle Position Sensor)

•How another sensors work

- Need for race car
- Don't need for race car

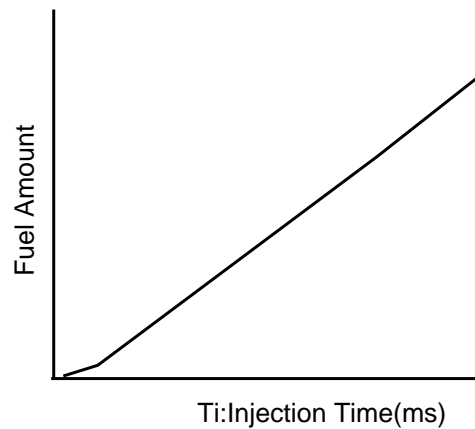
Engine Control System

- Understand how each component works.
- Select components to be necessary.
- Consider how to omit components not necessary.



Fuel injection amount characteristic

- Fuel amount is proportion to injection time.



How to determine injection time

<Example of automobile> Kect

Correction

Cal Tout

Qair
Ne Ti map

Kect table

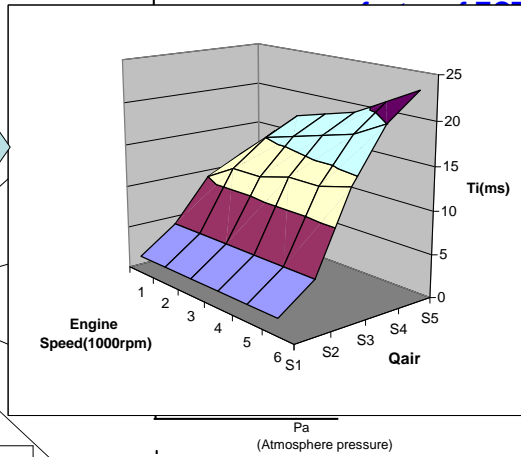
Kiat table

Kaps table

Cal Kaf

Tout=Ti*Kect*Kiat*Kaps*Kaf

END



A/F feedback correction factor

$$Kaf=1+Kp*dAF+\sum Ki*dAF+Kd*ddAF$$

$$dAF=AF-14.7 \quad ddAF=dAF_n-dAF_{n-1}$$

How to tune fuel (injection time)

<Example >

$$Ti(ms)=Ti(TPS-Ne)*Kmap*Kiat*Kect*Kaf$$

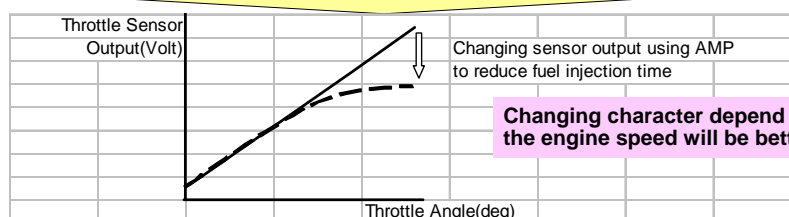
Choose what is necessary for race car

$$Ti(ms)=Ti(TPS-Ne)*Kmap*Kiat*Kect*Kaf$$

Think what is to be changed

$$Ti(ms)=Ti(TPS-Ne)*Kmap*Kiat*Kect*Kaf$$

How to change



Noise Control

- Noise level must be below 110dB(A) with certain engine speed.
- Recommend for use of **the original muffler**.
- The temperature of the exhaust manifold will be **over 500degC**.
- Consider the thermal expansion for the design.
- Prevent the damage to exhaust pipe by large-amplitude vibration.

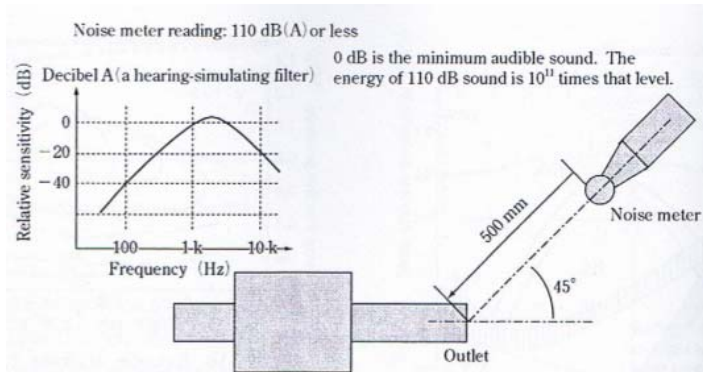


Fig. 10-17 Rules on Exhaust Noise

Electronics design

Service manual

1. Organizing Formula SAE rules concerning electrics.
2. Analyze the power supply systems (batteries, fuses, relays).
3. Analyze electronics of the engine and drive train control system.
4. Analyze electronics of the cooling system.
5. Analyze electronics of the fuel system.
6. Analyze electronics of the display system.
7. Decide your electrical systems for the race car.

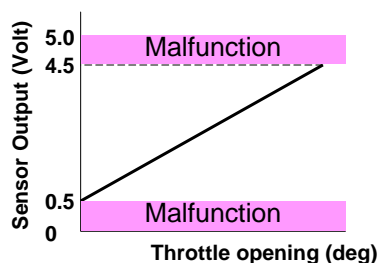
Electronics - Wiring Harness

- Recommend for use of original sensors, actuators, ECU, connectors of the base engine.
- You must make your own wiring harness according to the car design.
- Fuse box will prevent wire melting (fire) in case of short circuit.
- Choose correct wire size according to the current value.
- Ensuring the rated voltage values. Consider the wiring layout and size. **(Note) Voltage drop is huge during cranking!**
- Selecting connectors. **Contact error is popular problem.**
- Grounding potential is important (especially for sensor output).

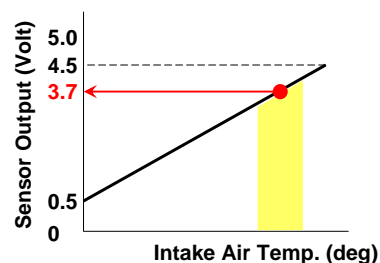


Electronics – Sensor, Actuator

- Recommend for use of original sensors, actuators, ECU and connectors of the base engine.
- Analyze sensor/actuator character.
- Decide to use, replace or eliminate.



You must understand the sensor character.



You can replace the sensor to the register.