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### Formulas

#### Horsepower and Torque:

Horsepower comes from torque. Torque is a result of the combustion process forcing the piston downward and rotating the crank. This output is measured as Torque. The idea is to generate high enough pressure on each stroke often enough (rpm) to generate the necessary Horsepower.

$$\text{Horsepower} = \frac{\text{Torque} \cdot \text{RPM}}{5252} \qquad \text{Torque} = \frac{\text{Horsepower} \cdot 5252}{\text{RPM}}$$

Horsepower and Torque, incidentally, are always equal at 5252 rpm.

Wanna figure out what that factory horsepower rating is at your height above sea level?

$$\text{Corrected BHP} = \text{BHP} \cdot (1 - ((\text{elevation}/1000) \cdot .03))$$

Note:

BHP = Brake Horse Power  
.03 = 1/30 mercury

#### Horsepower, ET, and Weight:

A quick calculation for horsepower based on 1/4 mile trap speed:

$$\text{HP} = (\text{TS}/234)^3 \cdot \text{race weight} \qquad \text{or} \qquad \text{HP} = (\text{TS} \cdot 0.00426)^3 \cdot \text{race weight} \qquad \text{where} \qquad \begin{array}{l} \text{HP} = \text{Horspower (of course)} \\ \text{TS} = 1/4 \text{ mile trap speed} \end{array}$$

This horsepower output is the mininum required for the specified trap speed. It assumes ideal track conditions, weather conditions, traction, and vehicle aerodynamics. It will understate horsepower required at speeds exceeding 100 mph.

$$\text{Weight} = (\text{ET}/5.825)^3 \cdot \text{HP}$$

Or try:

$$\text{HP} = \frac{\text{weight}}{(\text{ET}/5.825)^3} \qquad \text{for a quick idea of ideal ET assuming good street rubber and decent traction....} \qquad \text{ET} = \frac{1353}{\text{mph}}$$

#### Horsepower:

Calculation assuming sea level and known Volumetric Efficiency

$$\text{Horsepower} = \frac{\text{AP} \cdot \text{CR} \cdot \text{VE} \cdot \text{CID} \cdot \text{RPM}}{792001.6} \qquad \text{where} \qquad \begin{array}{l} \text{AP} = \text{atmospheric pressure in psi} \\ \text{CR} = \text{compression ratio} \\ \text{VE} = \text{volumetric efficiency} \\ \text{CID} = \text{cubic inch displacement} \\ \text{RPM} = \text{revolutions per minute} \end{array}$$

Most use Barometric pressure which is in measured in inches of mercury. To get the equivalent pressure in psi:

$$\text{Pressure}_{\text{psi}} = \frac{\text{pressure}_{\text{Hg}} \cdot 3376.85}{6894.757}$$

#### Air Filter Selection:

An average foam filter will flow 4.38 cfm/sq-in. A good paper filter will flow 4.95 cfm/sq-in. An oiled cotton gauze (K&N) will flow 6.03 cfm/sq-in.

To get your required filtered surface area for a oiled cotton gauze filter use the following formula:

$$\text{A} = \frac{\text{CID} \cdot \text{RPM}}{20839} \qquad \text{where} \qquad \begin{array}{l} \text{A} = \text{effective filtering area (square inches)} \\ \text{CID} = \text{cubic inch displacement} \\ \text{RPM} = \text{rev./min. at max power} \end{array}$$

Then using the following modifying factors if using an alternative filter media:

$$\begin{array}{l} \text{A} \cdot 1.3767 = \text{required surface area for foam element} \\ \text{A} \cdot 1.2181 = \text{required surface area for paper element} \end{array}$$

**Cubic Feet per Minute:**

$$\text{Theoretical CFM} = \frac{\text{CID} \cdot \text{RPM}}{3464} \quad \text{and} \quad \text{Actual CFM} = \frac{\text{CID} \cdot \text{RPM} \cdot \text{VE}}{3464}$$

VE = volumetric efficiency  
 CID = cubic inch displacement  
 RPM = revolutions per minute

**Carburetor Cubic Feet per Minute:**

$$\text{Required CFM} = \frac{\text{CID} \cdot \text{RPM} \cdot \text{VE}}{2820}$$

This seems to figure the requirement a bit larger than you'd think necessary.

**Volumetric Efficiency:**

Engine output is based on how much air and fuel it can burn. It's proficiency at burning the air/fuel mixture is defined as it's Volumetric Efficiency. If you know the amount of air your engine can move at a specific rpm you can use this calculation to estimate volumetric efficiency.

$$\text{Volumetric Efficiency} = \frac{\text{Actual CFM} \cdot 1728}{\text{CID} \cdot \text{RPM}} \quad \text{or} \quad \text{Volumetric Efficiency} = \frac{\text{Actual CFM}}{\text{Theoretical CFM}} \cdot 100$$

Or, if you know your horsepower at a given rpm (peak HP is what you want to use here) you can approximate your Volumetric Efficiency at sea level by using a variation of the previous Horsepower calculation:

$$\text{VE} = \frac{\text{HP} \cdot 792001.6}{\text{AP} \cdot \text{CR} \cdot \text{CID} \cdot \text{RPM}}$$

**Cubic Inch Displacement:**

CID = Number of cylinders \* 0.7854 \* bore \* bore \* stroke  
 All measurements in inches.

**Rev Limits:**

There are some rough standards for RPM limits. These are based on piston speed measured in feet per minute. Cast crank and rods should aim for under 3500 fpm. Forged crank, rods, and beefed main caps can handle closer to 3800-4000 fpm. This is *only* a rough estimate.

$$\text{Piston speed (fpm)} = \frac{\text{stroke} \cdot \text{RPM}}{6} \quad \text{and} \quad \text{RPM limit} = \frac{\text{Piston speed (fpm)} \cdot 6}{\text{stroke}}$$

fpm = feet per minute

**RPM vs. MPH:**

These calculations are useful in selecting rear tire diameters and rear gear ratios.

$$\text{MPH} = \frac{\text{Tire Diameter in inches} \cdot \text{RPM}}{336 \cdot \text{Diff Gear ratio} \cdot \text{Trans Gear Ratio}} \quad \text{RPM} = \frac{336 \cdot \text{Diff Gear ratio} \cdot \text{Trans Gear Ratio} \cdot \text{MPH}}{\text{Tire Diameter in inches}}$$

$$\text{Rearend Ratio} = \frac{\text{Tire Diameter in inches} \cdot \text{RPM}}{336 \cdot \text{MPH} \cdot \text{Trans Gear Ratio}} \quad \text{Tire diameter in inches} = \frac{336 \cdot \text{Diff Gear ratio} \cdot \text{Trans Gear Ratio} \cdot \text{MPH}}{\text{RPM}}$$

**Fuel Injectors:**

Just as the wrong sized jets in a carb can cause decreased performance and driveability problems, so can incorrectly sized injectors. The following calculation can be used for approximating fuel flow per injector based on horsepower (HP) and Brake Specific Fuel Consumption (BSFC).

Note:

- 1) Engine HP must be a realistic estimate.
- 2) BSFC is determined from engine dyno measurements. It typically ranges from 0.4-0.6 for gasoline engines. A BSFC of 0.5 is a safe, initial estimate.

$$\text{BSFC} = \frac{\text{Pounds of fuel per hour}}{\text{Brake Horse Power}}$$

3) The 0.8 multiplier for the "Number of Injectors" helps derive a practical "Max Injector Flow Rate" for each injector based on an effective real world injector operating pulse time and fuel flow. It is unrealistic to establish the fuel flow to an engine based on an injector operating pulse time of 100% (wide open all the time). This calculation uses an injector operating cycle of 80%. Some full race engine management systems may operate at 85-95% duty cycle, but extended operation may eventually overheat the injectors and cause irregular flow rates and poor low rpm operation.

$$\text{Injector Flow Rate (lbs/hr)} = \frac{\text{HP} \cdot \text{BSFC}}{\text{number of injectors} \cdot 0.8}$$

With a known injector fuel flow rate you can get a rough estimate of the systems capacity by using:

$$\text{HP} = \frac{\text{IFR} \cdot \text{number of injectors} \cdot 0.8}{\text{BSFC}} \quad \text{where} \quad \text{IFR} = \text{Injector Flow Rate (lbs/hr)}$$

Increasing the fuel pressure can often provide increased fuel flow and better atomization. If you know an injector's static (non-pulsed) fuel flow at one system pressure you can find its static flow at another pressure with this:

$$F_2 = \sqrt{\frac{P_2}{P_1}} \cdot F_1 \quad \text{where}$$

- F2** is the calculated injector static flow (lbs/hr) at the higher pressure
- P2** is the fuel system pressure (psi) you want to use
- F1** is the injector's static flow (lbs/hr) at it's rated fuel system pressure (psi)
- P1** is the fuel system pressure (psi) the injector is rated for