Selecting a Supercharger

Adapted from "Supercharged! Design, Testing and Installation of Supercharger Systems" (Corky Bell, Bentley Publishers, 2001)

When selecting a supercharger, we need to look at the following:

- Desired Power
- Required Pressure Ratio (and what boost that would be)
- Temperature Gain (because building boost builds heat)
- Density of the air (because hot air is not very dense)

Let's look at the formulas, and an example with a 302 Ford V8, using a typical roots-type supercharger. Let's use a typical stock 302 which produces about 220hp at 5,500 rpm, with a volumetric efficiency (Ev) of about 80%. Our goal is to produce 320hp at 5,500 rpm

Desired Power	(stock power) x (pressure ratio) x (density ratio) x (volumetric efficiencies ratio) x (drive power efficiency)	
We need to find out some of these variables first		
Volumetric Efficiencies Ratio	$\frac{\text{(supercharger volumetric efficiencies)}}{\text{(engine volumetric efficiencies)}}$	92% / 80% = 115%
Pressure Ratio	$\frac{\text{(desired horsepower)}}{\text{(existing horsepower)}}$	320psi / 220psi = 1.45
Boost	(1 - Pressure Ratio) x 14.7	(1 - 1.45) x 14.7 = 6.6psi

<table>
<tr><td>Temperature Gain</td><td>$$\frac{((PR^{0.28} - 1) \times T_{abs})}{0.55}$$</td><td>$((1.45^{0.28} - 1) \times 550) / 0.55 = 110^{\circ}F$</td></tr>
<tr><td>Density Ratio</td><td>$$\frac{\text{(Original absolute temperature)}}{\text{(Final absolute temperature)}}$$</td><td>$(460^{\circ} + 90^{\circ}) / (460^{\circ} + 200^{\circ}) = 0.83$</td></tr>
<tr><td colspan="3">Use the Power formula, solving for Pressure Ratio with the Density Ratio we just calculated.</td></tr>
<tr><td>Pressure Ratio</td><td>$$\frac{\text{(desired horsepower)}}{\text{(stock power x density ratio x volumetric efficiencies ratio x drive power efficiency)}}$$</td><td>$(320) / (220 \times 0.83 \times 1.15 \times 0.90) = 1.69$</td></tr>
<tr><td colspan="3">Use the new Pressure Ratio to find the new boost pressure.</td></tr>
<tr><td>Boost</td><td>$(1 - VER) \times 14.7$</td><td>$(1 - 1.69) \times 14.7 = 10.1$psi</td></tr>
<tr><td colspan="3">This means we need to run 10.1psi boost to overcome our various efficiency and heat losses. Unfortunately, this level of boost will heat the air more than we had estimated with the 6.6psi boost.
Re-calculate Temperature Gain and Density ratio with this new pressure ratio, then calculate another, newer pressure ratio and resulting boost.
If boost is within 1psi of our last calculation, we can stop. Otherwise, we need to run through the calculations again until boost doesn’t change any more with each re-calculation.
We need to run this calculation again, as we are almost 4psi different.</td></tr>
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Temperature Gain (2)	$((1.69^{0.28} - 1) \times 550) / 0.55 = 160^\circ F$
Density Ratio (2)	$(460^\circ + 90^\circ) / (460^\circ + 250^\circ) = 0.77$
Pressure Ratio (2)	$(320) / (220 \times 0.77 \times 1.15 \times 0.90) = 1.83$
Boost (2)	$(1 - 1.69) \times 14.7 = 12.2$psi
Not good enough. We're 2.1psi away from our last one. We need to do this again.	
Temperature Gain (3)	$((1.83^{0.28} - 1) \times 550) / 0.55 = 180^\circ F$
Density Ratio (3)	$(460^\circ + 90^\circ) / (460^\circ + 270^\circ) = 0.75$
Pressure Ratio (3)	$(320) / (220 \times 0.75 \times 1.15 \times 0.90) = 1.87$

Boost (3)	(1 - 1.87) x 14.7 = 12.8psi

Now we can stop. We are within 1psi of our last calculation.

Can you see how inefficient the roots type supercharger is? Do you see what's going on? Our "ideal" boost of 6.6psi should have given us the power we wanted, except heat becomes a problem and reducing power. To overcome these losses, we need to add more boost, which creates more heat, which gives less power, so we have to run more boost. We're essentially increasing atmospheric pressure 87% to give us a 45% increase in power.

We now know what kind of boost we need to run to get the power we want. Now we need to determine how much cfm the blower must pump to make that power. First let's look at how much the engine alone draws:

Basic Engine Airflow Rate	$\frac{(cid \times rpm \times 0.5 \times Ev)}{1728}$	(302 x 5500 x 0.5 x 0.80) / (1728) = 384cfm

Notice we multiply by 0.5 - this is because in one revolution, only half the engine has drawn air in. Now let's apply our Pressure Ratio to see how much we need.

Desired Airflow Rate	(Basic engine Airflow Rate) x (Pressure ratio)	(384) x 1.87 = 718cfm

Try to select a supercharger that will be most efficient when producing your desired airflow at your desired boost. Running a supercharger outside its efficiency range just produces heat, heat produces detonation, and detonation destroys engines. Your resultant airflow rate will likely be different than the supercharger size, so we need to spin the supercharger faster or slower to produce the exact volume we need. If the supercharger is measured in cubic inches, we need to convert it into cubit feet. Let's choose an Eaton M90 supercharger. It is 90ci per revolution.

Supercharger Volume in Feet	$\frac{\text{(Supercharger Volume in inches)}}{\text{(1728)}}$	(90) / (1728) = 0.052 ft^3/rev
Supercharger Speed	$\frac{\text{(Desired Airflow Rate)}}{\text{(Supercharger Volume in Feet)}}$	(718) / (0.052) = 13,808rpm

Now select the pulley size to be able to run that speed. Multiply the supercharger by this ratio to find your crankshaft pulley size. Try to be within 1/16" in diameter.

Pulley Ratio	$\frac{\text{(supercharger rpm at desired airflow)}}{\text{(supercharger internal gear ratio (if equipped) x engine redline rpm)}}$	(13,808) / (1 x 5500) = 1.95
Crankshaft Pulley Diameter	(Supercharger Pulley Diameter) x (Pulley Ratio)	(2.5) x (1.95) = 4.88in.