Calculation of air flow and pressure ratio required to meet horsepower target.

This is the method that I use. The values in the tables are the results from the calculations for my 998 turbo.

First determine your constants. These are typical values

Engine Capacity	1030	cc
Ambient Pressure	1000	mbara
Ambient Temperature	25	deg C
Intercooler Efficiency	80	%
Compressor Efficiency	71	%
Engine Volumetric Efficiency	90	%
AFR	12.50	
BSFC	0.50	Lb/hp/hr

Start with a boost value that you expect to give the required HP.

Generally 16 psi/1100 mbar will double your Naturally Aspirated horsepower.

Boost Pressure	800	mbarg

Then you need to select an rpm at which you want maximum power. You need to be realistic here and also consider your cam choice.

Rpm	6500	rpm

Pressure ratio is calculated by dividing the compressor outlet pressure by the inlet pressure in absolute pressure.

First subtract the pressure loss through the air filter from the atmospheric pressure

Ambient Pressure	1000	mbara
Pressure Loss thro Air Filter	50	mbarg
Compressor Inlet Pressure Abs P_1	950	mbara

The compressor outlet pressure is boost pressure plus atmospheric pressure

Compressor Outlet Pressure Abs P_2	1800	mbara

So compressor pressure ratio:

Compressor Pressure Ratio	1.895

Temperature rise due to compression is calculated as follows:

$$\frac{T_2}{T_1} = \frac{P_2}{P_1}^{[(n-1)/n]}$$

n = 1.4

Add 273 to Degrees C to get Degrees K.

Calculate the theoretical temperature rise and then divide by the compressor efficiency.

Compressor Inlet Temp	25	Deg C
Compressor Inlet Temp Abs T_1	298	Deg K
Compressor Outlet Temp Abs T_2	381.2	Deg K
Compressor Outlet Temp	108.2	Deg C

Calculate the theoretical air flow based on cc and rpm then apply the volumetric efficiency

Theo NA Air Flow	118	CFM
Actual NA Air Flow	106	CFM
	7.3	Lbs/Min

Calculate the density ratio from

$$\left(\frac{T_1}{T_2}\right) * \left(\frac{P_2}{P_1}\right)$$

Density Ratio	1.481

Multiply the actual NA air flow by the density ratio to get the air flow under boost conditions

Compressor Air Flow Turboed	158	CFM
	10.9	Lbs/Min

Next calculate the effects of the Intercooler

Inlet temperature to intercooler is taken as Compressor outlet temperature.

Intercooler Inlet Temp T_{in}	108	Deg C

The outlet temperature is calculated by

Inlet Temp – ((Inlet Temp – Ambient Temp) * Intercooler Efficiency)

Intercooler Outlet Temp T_{out}	42	Deg C

Make an allowance for pressure loss through the Intercooler

Intercooler Pressure Loss	75	mbar

Hence:

Intercooler Inlet Pressure P_{in}	1800	mbara
Intercooler Outlet Pressure P_{out}	1725	mbara

Calculate the density ratio (use absolute values)

$$\left(\frac{T_{In}}{T_{Out}}\right)*\left(\frac{P_{Out}}{P_{In}}\right)$$

Intercooler Density Ratio	1.161

Multiply the air flow calculated above by the density ratio to get the air flow under boost and intercooled.

Comp Air Flow Turboed & Int Cooled	183	CFM
	12.62	Lbs/Min

Calculate the HP per Lb/min airflow from the AFR and BSFC

HP per Lb/min Airflow	9.60	hp/lb/min

Calculate the horsepower by multiplying the air flow by the HP per Lb/min airflow

Approx.Power	121	hp
	89	kW