A Formula for Calculating Percent Power

Every once in a while, somebody will write to ask if there's an easy way to find out how much power an engine will deliver at a given altitude, under a given set of conditions (rpm, OAT, and so on). For years, our standard answer has been "no"—there is no *easy* way to derive the information. "Just refer to the performance charts in your owner's manual," we'd say.

Alfred P. Scott wasn't about to sit still for a lame answer, though. Scott—president of Sequoia Aircraft Corporation (and a notorious perfectionist)—can read a Lycoming Operator's Handbook as well as the next guy, but he wanted a genuine mathematical expression that could generate the points on Lycoming's power graphs. His resident "mathocist," Jim Petty (who developed the formula for the elegant curve of the Falco's fuselage frames), came to the rescue with the rather imposing equation you see here. (We thank Alfred Scott for sending it to us, and for letting us reprint it from the *Falco Builders' Newsletter*, where it first appeared.)

Two things to note: First, the lowermost equations are used to calculate important terms like Rm and Rf so they can in turn be used in the top (main) equation. So start at the bottom and work up.

Secondly: The lower equations (while probably representative of a good many engines) were specifically developed to fit the power curves of the Lycoming IO-320-B and IO-360-B. If you want formulas for other engines, you'll have to take the matter up with Messrs. Petty and Scott.

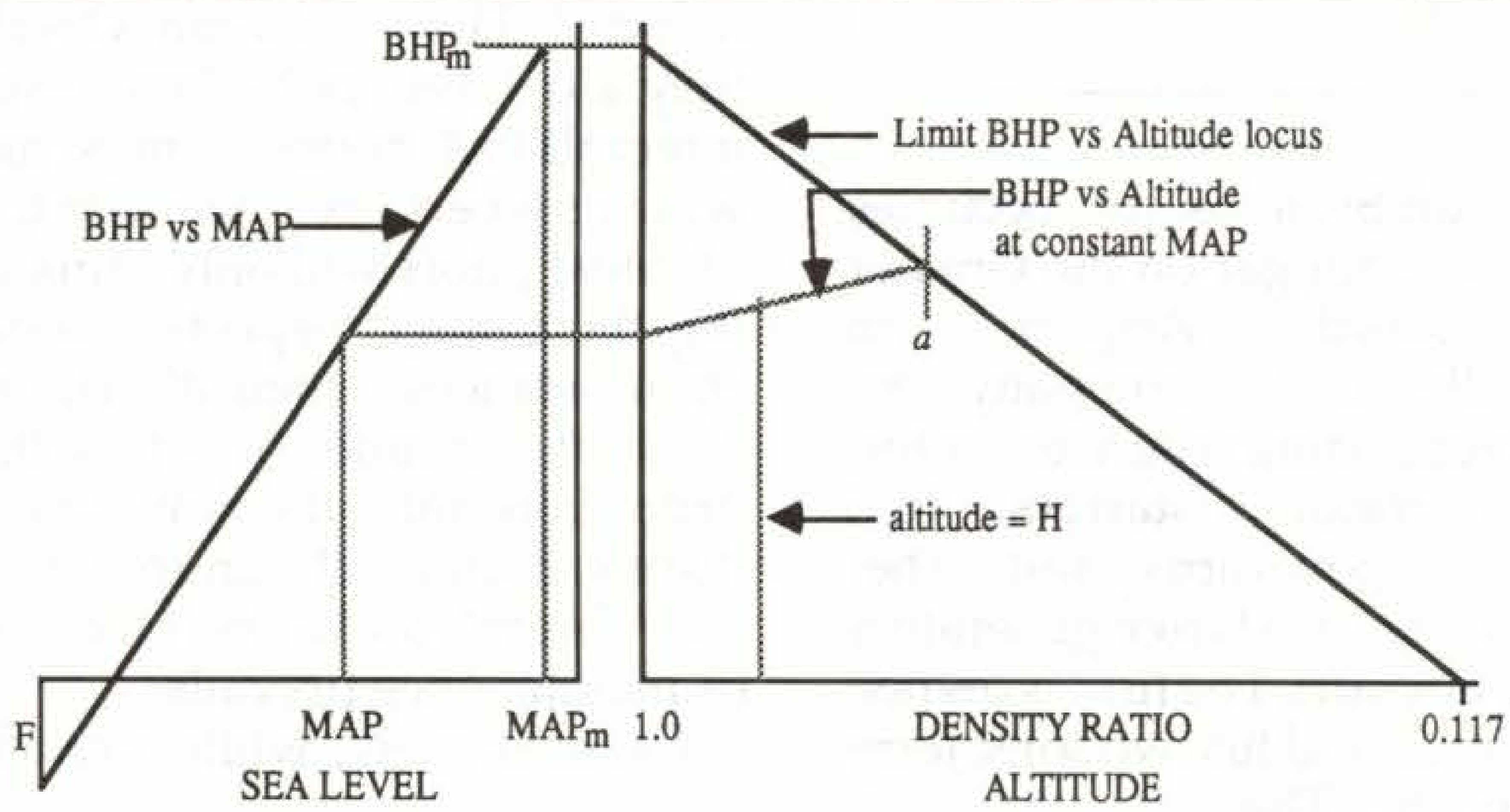
If you look at the temperature correction factor (Ct) equations, you'll recognize the standard lapse rate (3.566 deg. F per 1,000 ft), and of course pressure altitude (Hp); and our favorite fair-day OAT, 59 degrees, has been converted to degrees above absolute zero, which is only natural in calculations of this sort. (The presence of 145,350 in the density ratio formula merely signifies the end of the atmosphere at 145,350 feet.)

No corrections are given for ram effects or airscoop design (which is important in many planes), nor is propeller efficiency taken into account. Also, the accuracy of the equations is mooted by the fact that mixture isn't accounted for. Do the formulas assume best-power mixture? (One wouldn't think so, for full throttle at sea level anyway.) Peak EGT? Something richer than best-power? This is no small point, since the difference in horsepower between best-power mixture and best-economy amounts to something like 5%.

In any case, the Petty equation is tons of fun if you can program your PC to calculate the answers for you while you plug in rpm, OAT, and cruise altitude at will. But toting a computer around in the cockpit isn't feasible (for most of us). Power charts are still easier.

Who knows, though? Maybe somebody will load these formulas into a chip and tap into the cockpit gages to come up with a "percent power" display that reads engine output continuously in flight. (Insight? Alcor? Silver Instruments? How about it?)

—Kas Thomas



$$BHP_{corr} = BHP_m C_t \frac{[R_m - R_f(1 - R_m)](\sigma_{std} - R_m^{.81}) + \dfrac{(R_m^{.81} - .117)(1 - \sigma_{std})}{.883}}{1 - R_m^{.81}}$$

where: BHP_m = maximum sea level BHP for the RPM

$C_t = [(288.16 - 1.98111H_p/1000)/(273.16 + T)]^{1/2}$ = temperature correction factor for °C.

$C_t = [(518.688 - 3.566H_p/1000)/(459.688 + T)]^{1/2}$ = temperature correction factor for °F.

$R_m = MAP/MAP_m$ = manifold pressure ratio.

$R_f = F/BHP_m$ = friction horsepower ratio (a positive value; F is BHP at MAP = 0).

$\sigma_{std} = (1 - H_p/145350)^{4.25}$ = density ratio for standard atmosphere.

H_p = pressure altitude in feet.

T = outside air temperature in °C or °F at altitude H.

For Lycoming IO-320-B1A:

$BHP_m = 237.8 - .29438N + .00017626N^2 - .000000028671N^3$

$R_m = MAP/(30.16 - .000386N)$

$R_f = -1.4184 + .0016437N - .000000373N^2$

For Lycoming IO-360-B1E:

$BHP_m = -2.6 + .09285N - .00000902N^2$

$R_m = MAP/(30.65 - .000557N)$

$R_f = .235 + .0000063N$

where: N = RPM

MAP = manifold pressure in inches of mercury.