KENNE BELL

SUPERCHARGER EFFICIENCY, SIZES, RATINGS & BOOST EXPLAINED

"My supercharger is more efficient than yours." "The ____ supercharger makes more power." These are typical remarks heard during any supercharger bench racing session. Since 1991, we've fielded hundreds of calls and email per week - sometimes per day - about supercharging. Recently, it occurred to us that perhaps a basic easy to understand discussion on supercharger efficiency might pre answer many of these questions. So, our goal is to provide you with a thorough and informative overview of the basics of supercharging, ratings and the 3 areas of supercharger efficiency.

UNDERSTANDING BOOST PRESSURE

God gave us 14.7 psi of boost at sea level. This is simply the weight of earth's 100 mile high atmosphere. At 5000' in Denver, Colorado, this "God's boost" would be only 12.2 psi, as the atmospheres height at 5000' is only 99 miles high vs 100 miles at sea level. So, of course, your non supercharged engine will perform better at sea level where it has more boost (14.7 vs 12.2). Without this atmospheric weight or "boost," the engine would not run. Why? Because an engine creates a vacuum as it rotates thereby allowing the higher pressure atmosphere to rush in and fill the vacuum with 14.7 psi of boost. Note: This boost does not show up on a typical 0-20 psi / 0-30" Hg gauge as 14.7 but instead as "0" on the 0-30" Hg scale. Now imagine, on an ascending scale, that the 30" Hg is 0 psi and the 0" Hg is 14.7 psi and you have an "absolute" pressure gauge. Add the 20 psi to the 14.7 psi and the gauge markings would be 0-34.7. Floor the throttle at sea level and the gauge will read 14.7 psi and 12.2 psi in Denver (with "0" inlet restriction). With a supercharger and 6 psi boost, your new absolute pressure gauge will read 20.7 (14.7+6=20.7) at seal level and 18.2 (20.7-2.5=18.2) in Denver. Here's how you determine if your engine is utilizing all of "God's boost." If the gauge reads 4" of vacuum at wide open throttle, your engine is losing 13.6% of it's power or 2 psi of "God's boost." This is a simple equation that few really understand. 2 psi lost÷14.7=13.6% HP loss. To eliminate the pressure losses, install larger non restrictive inlet components (filter, MAF meter, throttle body and/or inlet manifold). The 2 psi loss with a 6 psi kit (18.7 psi absolute) is 2÷18.7=10.7% HP loss. This is a big number as 10.7% of the supercharged HP is 32 whopping HP on a 300HP engine. Whether fuel injected or carbureted, ALWAYS try for a "0" reading. That's the way we've done it at Kenne Bell since the 60's. O.K., now let's talk a little about choosing a supercharger.

There are many factors to consider when purchasing a supercharger. Before making a decision, one should first understand the basic terminology (size, ratings, volumetric efficiency, thermal efficiency and adiabatic efficiency). We will attempt to make this a no B.S. straight forward overview of supercharging.

SUPERCHARGERS

A supercharger is merely an air pump that pumps more air into the engine than the engine, which is also an air pump, can discharge or exhaust. The excess air from the supercharger creates a back pressure which we commonly refer to as boost. 1 psi of boost is approximately 20RWHP. For example: A good 400HP engine is pumping out or sucking in approx. 6000 cfm at 6000 rpm. See Kenne Bell FAQ's "I'm confused about cfm and HP". So if the supercharger pumps 1000 cfm into the 600 cfm engine, the result will be a back pressure build up (boost). The more air the supercharger pumps in, the higher the boost and the greater the HP output.

VOLUMETRIC EFFICIENCY

If boost drops off with an unrestricted inlet as engine rpm increases, that is a tell tale sign the supercharger volumetric efficiency (air cfm in vs. air cfm out) is dropping off. For example, that's exactly what happens with the Eaton supercharged '03 Cobra. It loses 3 psi boost from boost drop off (13-10 psi) and the HP from the lower boost decreases power by 39HP (1 psi=13HP) Then there's the higher power consumption/parasitic loss of the Eaton. More on that later. Volumetric efficiency indicates how efficiently the supercharger breathes and leaks. For example: If a supercharger has a displacement of 10 liters but only 7.2 liters exits the supercharger, then it has a 72% efficiency. 7.2÷10=72%. It's as simple as that. When the VE drops off, so will the cfm, boost and engine HP. If the VE is low, the boost is low. Remember, lower cfm supercharger output equates to less boost. Boost will not drop off with a supercharger that has a high volumetric efficiency throughout the engine's rpm band. The Kenne Bell Twin Screw supercharger maintains the same rated boost throughout the engine's rpm, so the Twin Screw enjoys a high VE at any engine rpm. At higher boost levels in the Mustang, Lightning, Cobra, LS1-LS2-LS6 and Hemi's, the smaller displacement 1.5-2.3L Eatons VE drops sharply. Centrifugals have a relatively poor VE in the low and mid range rpm band, but are equal to the Twin Screw at peak boost.

ADIABATIC EFFICIENCY (OVERALL EFFICIENCY)

Basically, this indicates how efficiently the supercharger utilizes the energy (HP) that "drives" the supercharger. A high adiabatic efficiency means the supercharger consumes less energy (HP) from the engine to drive it, thereby leaving more engine power for acceleration - and higher dyno numbers. A low adiabatic efficiency means the engine must "waste" more of it's HP output to drive the supercharger. This is a very important consideration because the higher the parasitic loss/power consumption of the supercharger, the more HP your engine must "waste" to drive it. This clearly shows up on a Dynojet when 2 superchargers are tested on the same engine with equal boost. Two superchargers may have comparable volumetric efficiency (VE) but one may have lower power consumption (higher adiabatic efficiency). See "Twin Screw vs. Roots".

TEMPERATURE EFFICIENCY

Temperature efficiency is the difference between the temperature entering the supercharger as compared to the boosted discharge air temperature. Superchargers with lower air temperatures are more "temperature efficient" than those with hotter discharge temperatures (See "Twin Screw vs Roots"). Be aware that a temperature reduction AFTER the supercharger will typically not make more HP - as many experts would falsely lead you to believe. At Kenne Bell, we understand intercooling. We've been doing it since 1987. Today we offer the exclusive BIGUN series intercoolers. Look at it this way. Your supercharger discharges 90 cfm of air in one revolution. Now let's trap all that air in a balloon. The oxygen in the balloon will always weigh the same regardless of how much it is cooled. Then how can this trapped air magically acquire more oxygen molecules? It cannot. Cooling air after the supercharger cannot make more power and therefore, intercoolers do not increase HP from "more oxygen." When will everyone out there get this right? The cooler air will, however, allow the engine to run more ignition advance and/or more boost on a given octane. Obviously, cooler denser (WITH higher oxygen content) air entering the supercharger increases power at the rate of 1% for every 10°. So lose that power robbing underhood exposed filter.

SUPERCHARGER RATINGS & OUTPUT

Superchargers are rated by liters (L), cubic inches (cfm). For example; An Eaton 90 (90 cu.") is actually 1.5L. One should exercise extreme caution in using supercharger "ratings" as the only criteria in selecting a supercharger. These ratings can be deceiving. Just look at the differences in HP and efficiencies between the Eaton 90 (1.5L) and Kenne Bell 1500 (1.5L). See comparison tests on our website (dyno test comparison "Positive Reinforcement - Eaton vs. Autorotor in a Supercharger Slugfest" and "Snake Bite Hit" (Eaton 112 vs. Kenne Bell 2.2).

Now that you understand the 3 basics of supercharging, let's assume that two superchargers have identical 1. volumetric efficiency 2. power consumption/parasitic HP loss and 3. discharge temp at 6000 engine rpm. Further assume these superchargers take turns blowing air into an engine at 6000 rpm. Since an engine has no eyes or fingers, it cannot possibly distinguish between the 2 superchargers. The engine only sees air flow/cfm and boost. Subsequently, the superchargers will both produce the same boost/HP. Why? Again, the 1. power consumption 2. cfm/boost and 3. temp are identical. There is no "4th dimension" or unknown source of magic power that will make one supercharger produce more power than another. Let's summarize: If 2 unrestricted inlet superchargers, regardless of type or manufacturer, have the same VE, power consumption and discharge temp at a specified engine rpm, then both will produce exactly the same peak HP. If more power is required, then raise the boost level. Boost is what makes the power. That's what superchargers do. They make boost. However, it is very important to understand that they don't all make the same boost at 2000, 3000, 4000 and 5000 - so they cannot possibly produce the same HP at 2000, 3000, 4000 and 5000. For example: Centrifugal superchargers are also very efficient, but only at higher engine speeds where they produce the most cfm and boost. At lower engine speeds, the centrifugal produces proportionately less air and, therefore, less boost (engine back pressure) and power than positive displacement superchargers.

The Twin Screw produces approx. the same boost at any engine rpm. Every revolution of the Twin Screw delivers the same cfm or liters per revolution i.e. 2L per revolution at 2000-6000. That's why these superchargers are referred to as "positive displacement." Unlike a positive displacement supercharger, the centrifugal might produce 1/2 L @ 1000 engine rpm, 2/3L @ 2000, 1L @ 3000, 1-1/3L @ 4000, 1-2/3L @ 5000 and finally 2L @ 6000. That's because the centrifugal relies on engine speed to generate exponentially higher cfm/L - and boost. Boost is approx. 1 psi per 1000 rpm on a 6 psi centrifugal kit whereas the boost may be 6 psi at 2000-6000 on a positive displacement type.

The centrifugal boost curve is not exactly linear as indicated above, but it's close enough for discussion. For example: Here's an actual test. 11 psi at 6000, 7 psi @ 5000, 4.5 @ 4000, 2.5 @ 3000. What's important to remember is that the Twin Screws pump out approx. the same displacement or cfm per revolution at any engine speed. Twin Screw efficiency (actual displacement or cfm discharged) will depend on the overall design of the supercharger itself. Besides VE, temperature efficiency and power consumption, a superchargers construction and it's reputation for performance, reliability and longevity are also important considerations. Equally important is the manufacturers reputation for tech support and service.