HORSEPOWER & TORQUE

by Robert Szabo

The main goal of most IHRA drag racers is horsepower. For classes with no elapse time ceiling, that is the ongoing engine development task. For sportsman and bracket classes, a horsepower target must be reached so that an elapse time goal can be achieved or exceeded. When that goal is reached, the IHRA racecar is run at a reduced power or performance level to achieve a target elapse time. The extra power is available to dial down in some cases or to compensate for air density losses. But even most of these racers strive for the next power level of achievement. Many 9.90 Hot Rod racers would not mind the discovery of new power for 8.90 Quick Rod performance.

HP OR TQ: The engine development task throughout the racing community is often stated as: "more horsepower or more torque?" An engine with maximum horsepower is thought of as a high-end power engine that does not have much mid range torque. One with maximum torque is thought of with limited horsepower at the high end.

NOT A FAIR QUESTION: Unfortunately that is an understatement. Torque is twisting force. Horsepower is that twisting force at an engine speed. An engine with "maximum horsepower" also has torque. An engine with "maximum torque" also has horsepower. The torque of the engine at any engine speed determines the horsepower of that engine at that speed. Engines have a torque and a horsepower at all engine speeds, there are just varying amounts. The reduced torque at lower speed from the max HP engine is a result of parts and tuning that are inefficient at low speed but very efficient at high speed.

EXPLANATION: Recall the math relationship between horsepower and torque:

HP = (TQ X RPM) / 5252

ILLUSTRATION #1: Compare two engines. One is the 325 horsepower 396. The other is a 425 horsepower 396. Both engines were available in the 1965 full size Chevrolet. Only a couple hundred dollars separated the two as options. Yet the choice was highly argumentative to the drag racers of that day.

TQ: The 325 engine had 430 foot-pounds of torque at about 3,600 RPM. The 425 engine had only 415 foot-pounds of torque at 4,300 RPM. The 325 engine was the torque king.

HP: The first engine had 325 horsepower at about 5,200 RPM. The other had 425 horsepower at 6,400 RPM. The second was the horsepower king. These ratings were gross ratings without mufflers and accessories. Which engine was the grudge race king: the first one with more torque or the second one with more horsepower? Most racers now accept the second engine as the drag race king. However at that time, many ordered the first engine with the greater torque as the selection for drag racing a 4,300 pound sedan.

HP @ PEAK TQ: Both engines are now compared for horsepower at their torque peak values. The horsepower of the first engine at its torque peak is:

HP = (TQ X RPM) / 5252
HP = 430 X 3,600 / 5252 = 295

The horsepower for the second engine at its torque peak is:
HP = (TQ X RPM) / 5252
HP = 415 X 4,300 / 5252 = 340

The 425 engine has an advantage here. The HP of the 425 engine at 3,600 RPM was less than 260. This value was a lot lower than 295, the horsepower of the 325 engine at 3,600 RPM. That is the rub. The 396 truck engine had even less horsepower at the high engine speeds but more torque at lower engine speeds. This was another rub. Which engine would pin you in the seat more? That was entirely dependent on transmission & rear end ratio gearing AND the speed. Compare a vehicle with one engine to another vehicle with the other engine. Both are delivered with 3.31 ratio rear end gears and close ratio 4 speeds. The 325 engine would get to about 40 MPH faster than the 425 engine. Beyond that, the 425 was making more torque winding at 40 MPH and above than the 325 winding at 40 MPH and above. That was the case even though it was not making more than the peak torque of the 325 at the lower speed. This leads to the issue of what speed is the torque made.

ILLUSTRATION #2: An engine planner selects a normally aspirated engine speed of 5,252 RPM for maximum performance and the optimum parts for that speed. An experienced engine builder puts the combination together that makes peak torque at 5,252 RPM. The intake port sizes, cam timing, and ignition advance are all optimized for that speed. The ports and cam timing are too small for higher engine speeds. The ignition advance is too low for the higher engine speed. Assume that this engine squeezes out 400 foot-pounds of torque at 5,252 RPM. The horsepower would be:

HP = 400 X 5,252 / 5252 = 400

That is the speed for all engines that HP and TQ are the same. If this engine is truly at maximum and every last foot-pound of torque is squeezed from the tuning values, then the engine would not have as much torque at lower or higher engine speeds. Likewise it would not have as much horsepower at lower speeds. However, it may have more horsepower at higher speeds. Assume the torque drops off 3 % at 500 RPM higher. That would be 384 foot-pounds at 5,752 RPM. The horsepower would be:

HP = 384 X 5,752 / 5252 = 420

Even though the torque is less at higher speed, the engine horsepower is more. In fact, consider an engine with a maximum power band at a single RPM. The engine RPM for peak torque and RPM for peak horsepower are close to the same value (or in some cases the same). It requires a close ratio 5 or 6 speed transmission or an ultra high stall speed torque converter. That converter allows the engine to remain at high RPM in the power band for both torque and horsepower. That is not the case for an engine with a wider power band. The two RPM values are separated somewhat. Usually the torque ends up at a lower speed and a greater value. The horsepower is also a lower value although it may remain at a high engine speed.

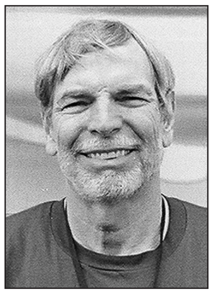
RELATIVE TO IHRA RACING: What is more desirable, an engine with high horsepower or an engine with high torque? Again, in IHRA classes with no elapse time ceiling, racers are talking high horsepower. Bracket class racers are talking both. The automatic transmission suppliers are asking for the peak torque speed and the torque amount. What is all of this? Consider an engine with a higher peak torque (crankshaft twist) at low speed. How is it out-powered by a high horsepower engine with lower peak torque (crankshaft twist) at that low engine speed? The answer has to do with the torque AT THE TIRE, AT THE RACECAR SPEED. Higher torque (at the tire) can be achieved with a high RPM race engine with gearing. The most twisting force at the highest engine speed becomes the goal.

COMBUSTION TORQUE: An engine of a particular size can be tuned with intake port size, cam timing, and spark advance to make a given amount of combustion torque. That combination can produce the optimum combustion torque at low RPM. Or it can be a different selection of parts to make optimum combustion torque at high RPM. Regardless of the speed, it tends to be determined by the displacement of the engine for normally aspirated setups. For supercharged engines, it tends to be determined by the displacement of the supercharger.

FRICTION AND PUMPING LOSSES: Unfortunately, as the engine speed is increased, frictional losses and air / fuel pumping losses increase. A drag racing mountain motor can have over 300 foot-pounds of frictional & pumping torque losses. It makes 1,100 foot-pounds. That is what is left after the losses. The higher the speed, the less the engine torque left over. However it is at a greater speed. Because of the higher engine speed, gearing can increase the torque output from the transmission and rear end to increase acceleration of the vehicle. The high engine speed makes gearing the ultimate band-aid.

BEST COMBINATION: This leads to the engine planner's age-old task: (1) what engine speed for the torque peak and (2) a lower value with a wide range vs. higher value with a narrower range. Torque converter equipped racecars and those with two speed transmissions that pull the engine down a couple thousand RPM are a challenge for the second task. Two and three speed transmissions in the higher power racecars are also in this category. Shifting the transmission pulls the engine down 1,500 to 2,000 RPM. The engine must accelerate over a wider speed range. It must make good torque over a wider range. That task is done by the skill of an engine planner, the one who selects the combination of parts, and the skill of the builder who puts those parts together. That is at the expense of maximum horsepower. Then the skill of the one who does the gearing and torque converter selection completes the task. Some of us do all of that ourselves. Some buy an engine, trans, and gearing combination from an experienced supplier. In any event our success is dependent on a very high skill level. The winner's circle is often the measure of the achievement of the best combination. That results from the best combination of combustion torque with the least frictional and pumping torque losses, at the highest engine speed, with the best gearing to use it.

THE RESULT: Your moderate torque race engine can be geared with racing converter, trans, and rear end to make wheel-spinning torque all the way through low gear. A truck engine can also be geared to make wheel-spinning torque through low gear. However, your race engine at 9,000 RPM gets to 80 MPH before the shift into second gear settles it down. The truck engine gets to 4,500 RPM, about 40 MPH, for the shift into second gear. From 40 up, the truck is stuck with a lower torque output gear. Then at 70 MPH the truck has to shift again into third for an even lower torque output. That is the difference between a race setup and a truck setup. The measure of performance is horsepower. Horsepower is torque at RPM. High horsepower is a high combination of torque & RPM. A truck engine can equal or outperform a racing engine at low speed. But to get up to high speed, the race engine with proper racing gear does it much better. No it will not last at 9,000 RPM pulling a heavy trailer load over the Smokey's. For that we have truck engines.•



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Bob Szabo is an owner / driver of a blown alcohol drag racecar and author of the technical book: "Fuel Injection Racing Secrets." The author's next book is on methanol racing fuel that is a couple months away. Check the DRM Yellow Pages for Szabo Publishing or look on the Internet at http://www.racecarbook.com or call (707) 446 2917. If you have any comments about this article or any previous articles by the author, feel free to e-mail directly to the author at bob@racecarbook.com or to the DRM staff: pamelamarchyshyn@livenation.com or michaelperry@livenation.com