Finding the Facts With Formulas

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Contributing Editor

Transmission shops are called upon to perform a wide variety of repairs for their customers. Much of the work entails repairing or rebuilding driveline components that are broken or worn out. Then there are customers who want some form of customization for their vehicles in the hope of improving performance or fuel economy. Situations arise when a shop gets involved with a vehicle that has been modified previously, or when some swap or change of transmission or differential is being contemplated.

Customers want the "latest and greatest" and tend to follow trends that may improve performance. Transmission and differential ratios, oversized wheels and tires, lift kits, reversed wheels etc. all have a huge effect on vehicle handling and performance, and many times this change is in the wrong direction.

To advise your customers properly and to have a fighting chance at fixing somebody else's screw-up, you need to have some base-line information to rely on. Here are some formulas that you can use to arrive at facts instead of some of the hype and fiction that are advertised in the marketplace.

Ratios

We get lots of calls with ratio questions, and I am surprised at how something simple seems to confuse so many people. To arrive at a gear ratio you divide the number of teeth on the *driven gear* by the number of teeth on the *drive gear*. The simplest ratio is that of the ring and pinion. If the pinion (drive gear) has 10 teeth and the ring gear (driven gear) has 41 teeth, divide 41 by 10 and the final-drive ratio is 4.10-1.

Transmission ratios are just as simple, except that we have to calculate two ratios. First we divide the number of teeth on the input journal of the countershaft by the number of teeth on the input shaft. We now have the input ratio. Now divide the number of teeth on the driven gear (speed gear) by the number of teeth on the counter gear (drive gear) to get each speed-gear ratio. Once you have the speed-gear ratio, multiply it by the input ratio to get the output ratio of the transmission in each speed. Remember, it is driven gear divided by drive gear. This is important in figuring out overdrive ratios, as you will be dividing a small number by a large number and the answer will be fractional. Multiplying the fraction by the input ratio will give you the overdrive ratio, which is always less than 1-1.

Now that we have the ratios for each speed gear in the transmission, we can multiply each speed-gear ratio by the final-drive ratio. This will give us the *overall ratio* for each gear at the axle. This is the groundwork for predicting the effects of gear changes when a customer asks you to install the latest trick widget that his brother-in-law recommended.

Another extremely common problem to find its way into your shop is the large number of vehicles whose owners have replaced the original wheels and tires with non-stock sizes. Customers think it is cool to customize the car and usually give little or no thought to the effect these changes will have on the transmission, differential, brakes, suspension, and computer or speedometer calibration. How many shops have chased an early or late shift problem in an automatic trans without first checking to see whether

Chart 1
Driveshaft Torque

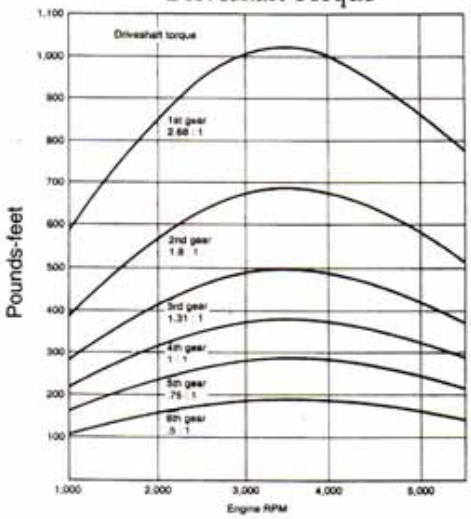


Chart 2
Rear-Wheel Torque

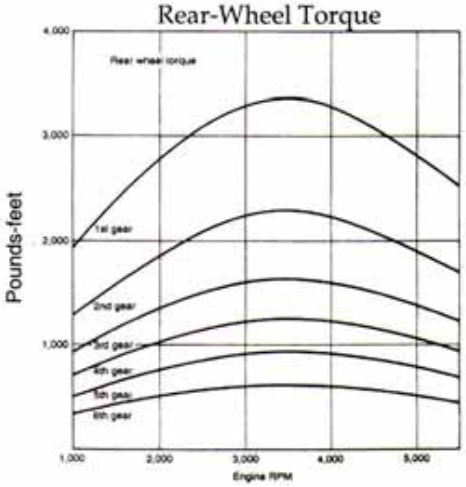
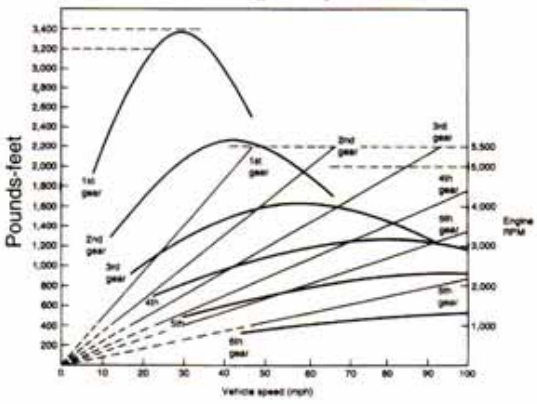


Chart 3
Driving Torque



the tires and wheels are OEM sizes? There is a simple formula used to determine the changes in speed produced by a change in tire or wheel size. A variation of this formula will calculate the change in engine speed resulting from a change in tire size.

MPH (miles per hour) = RPM X tire diameter divided by gear ratio X 336.

Engine RPM = MPH X gear ratio X 336 divided by tire diameter.

Note: To factor out differences caused by tire pressures, measure the tire diameter "loaded." Find the radius of the tire by measuring from the centerline of the axle to the ground, and multiply by two to get the diameter. Using this figure for your diameter will be more accurate.

Carmakers proudly advertise torque-rating numbers for all their engines. These numbers help sell cars, but to anyone involved in racing and vehicle performance, engine torque ratings by themselves are useless. The engine torque rating has no basis in reality; torque available at the drive wheel is what matters. Torque generated on an engine dyno is subject to driveline ratios, tire sizes and parasitic losses. The only torque rating that is meaningful is obtained on a well-calibrated chassis dyno. In case you don't have one of these machines at home, you can calculate the numbers using the following formula:

DT = Te X Rt X Ra divided by r

DT is driving torque or motive force, in pounds-feet

Te is engine torque in pounds-feet

Rt is transmission gear ratio

Ra is drive-axle ratio

R is "loaded" radius of the drive wheel in feet (measure the radius with the car on the ground).

The charts included show various torque curves and how they change with gear ratios. Chart 1 illustrates driveshaft torque, which is obtained by multiplying engine torque by transmission gear ratios. Chart 2 shows the torque available at the drive wheel, which is calculated by multiplying driveshaft torque by final-drive ratio. Chart 3 graphs driving torque at various road speeds and gear ratios. To obtain that value, divide the torque available at the drive wheel by the radius of the loaded tire in feet.

These charts show the effects of any changes in gear ratios and tire sizes. With the stock setup as a base line and some simple arithmetic, you will be able to compare any proposed changes on paper before using up any valuable labor. You now can provide some expert advice and prevent some disappointments. This knowledge also will help you track down some tough drivability problems that may have occurred at other shops before the car wound up at your door.

It is very easy in this business to get so involved in the day-to-day battle that we overlook a lot of theory. Understanding the theory of operation of the driveline components will make your diagnostic and repair skills complete. To this end there are two books in print that should be required reading for everyone in our industry who seeks to be a true professional. The books are a worthwhile investment.

Manual Drive Trains And Axles
By Thomas Birch
Publisher: Prentice Hall

Manual Transmissions And Transaxles
By Jack Erjavec
Publisher: Delmar TD

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