TWISTER

MOTOR TUNING GUIDE

by Mike Walker

What's the difference between wet magnets and dry magnets? Why does my neighbor's 15 turn motor walk all over my 13 turn motor? Am I doing something wrong?

These are the types of questions we hear many times each day on the TWISTER MOTOR HOTLINE. In response to these questions, and the success enjoyed by our customers who we have helped, we have created the TWISTER MOTOR TUNING GUIDE. This should answer most of your questions, but if it doesn't, call the TWISTER HOTLINE.

THE BASICS

Let's kick things off with motor basics. Motors may look different in outside appearance, but they all share many common characteristics. Radio control racing motors use three pole armatures, permanent magnets and operate on direct current. Stock motors feature Oilite bushings, end bells without adjustable timing and machine-wound armatures with 27 turns of 22 AWG wire. Open class motors use ball bearings, adjustable timing end bells and have armatures that may be hand or machine-wound. Magnets may be of the wet or dry type.

WET OR DRY MAGNETS

Whether a magnet is WET or DRY refers to the method of manufacture. Magnets are made by pressing a wet or dry powder into a mold. The "WET" process improves the grain structure of the magnet. Usually stronger, wet magnets more effectively resist damage from outside magnetic fields, high heat and impacts, all major considerations in RC racing. Although our Yokomo based TWISTER MOTORS feature a high quality "WET" magnet, the term "WET" magnet is no guarantee of quality. Wet magnets can be, and often are, poorly made.

MAGNETS

Magnets affect the performance of a motor. It is very important to understand the effect of the strength of the magnetic field on power and the "notchy" feel of the motor. The "notchy" feel of a motor is effected more by the air gap between the magnets and the armature than it is by the strength of the magnetic field. Don't try to judge the condition of a motor by spinning the armature. Contrary to popular belief, the stronger magnetic fields created by wet magnets do not usually increase overall power. Wet magnets increase torque and reduce the rate of acceleration, R.P.M.s and amperage draw of the motor. Remember that electrical power is measured in Watts. The formula to determine Watts is amps x voltage = Watts. A reduction in amperage draw reduces the amps in the equation, and therefore, actually reduces the power output.

To understand why stronger magnetic fields reduce amperage draw, it is helpful to understand how electric motors work. Motors are generators. When electricity is applied to the motor to run something, like your RC car, it works as a motor. If a force, like wind or flowing water, turns the motor, it will generate electricity (visit Hoover Dam sometime). When a motor is running, it actually generates what is known as back electromotive force. Back EMF is voltage created in the opposite direction to the voltage being applied to run the motor. As the motor speed increases, the back EMF voltage eventually equals the input voltage (disregarding mechanical and aerodynamic drag in internal motor inefficiency losses). When the opposing voltages are equal, the motor will run at a constant speed, drawing minimum amperage. The slower the motor is spinning, the less the back EMF voltage is being generated and the more amps the motor can draw.

How does all of this relate to magnets? Simple! The stronger the magnetic field (as with wet magnets), the better the motor generates back EMF and consequently uses less amperage. Because of the stronger EMF with wet magnets, it becomes necessary to use hotter armatures to overcome the more intense magnetic field. That's why it takes a 13 turn wet magnet (hotter) motor to equal the power and amperage draw of a 15 turn dry magnet (milder) motor.

Because of the reduced power (especially at high RPM) caused by the higher magnetic field strength, oval motors should never be re-magnetized. Re-magnetizing is an overrated process that is rarely effective and therefore unnecessary. Old motors don't slow down because the magnets go away. They lose power because the brushes, bearings or commutator have worn out.

STOCK MOTOR TIMING

Before we leave the topic of general motor information, the recent controversy concerning stock motor timing needs clarification. Most of the hotter stock motors for RC racing have 30 to 36 degrees of built-in timing. Stock motors rarely run hot or short out due to excessive timing. They usually run hot because of inadequate oil on the bushings or too high a gear ratio. Most shorts occur because the armature was too tightly wound during manufacturing. This can cause the sharp edge of the armature to cut through the wire insulation resulting in a short. We seem to have reached the practical limits on stock motor timing. Adding additional timing would probably reduce low speed torque too much. It's doubtful, despite everything that you have been reading recently, that the manufacturers will continue their "timing wars".

MOTOR BREAK-IN

Motor break-in is a very controversial and misunderstood subject. It's as though every racer has a different method for break-in, with some sounding wild enough to curl your hair. New motors or brushes do not require excessively long break-in periods. A few minutes is all that is needed to insure maximum performance and long life.

STOCK MOTOR BREAK-IN PREPARATION

The following steps should be followed to properly break-in a stock motor. Place two or three drops of oil (10 - 20 WT) on each motor bushing. The bushings in stock motors are oilite bushings and they are designed to absorb oil, so they must be thoroughly oiled when new to prevent dry running. Slide the armature shaft back and forth and rotate it a few times by hand to allow the oil to spread between the shaft and the bushing. After the break-in period, place a drop of oil on each bushing before every run. It is better to use too much oil than to use inadequate amounts. A lack of oil can cause the motor to run too hot, leading to premature bushing, brush or commutator failure. If you get oil on the commutator, just give it a little shot of motor spray to remove the oil.

MODIFIED MOTOR BREAK-IN PREPARATION

The following steps should be followed to properly break-in a modified motor. Apply one drop of oil (10 WT or less) to each bearing. Ball bearings do not need excess oil like oilite bushings. Excess oil will attract dirt and mess up the commutator. Remove any excess oil with motor spray as you would with a stock motor.

BREAK-IN PROCEDURE FOR ALL MOTORS

The actual break-in procedue is the same for stock or modified motors. The motor must be run at low speed, between 3 and 4 volts, for a safe break-in. TWISTER recommends using comm drops or a light shot of motor spray or contact cleaner on the commutator. This will help lubricate and cool the brush to commutator contact surface and will insure proper break-in without damaging the commutator.

Let the motor run for 5 minutes. Use a squirt of motor spray on the commutator every 60 seconds while the motor is running. This cleans away the brush dust and keeps the commutator temperature lower to prevent distortion. Spray the motor one last time to clean the commutator. Then let the motor run for 2 minutes to dry out. After 2 minutes, disconnect the motor.

The purpose of this low load, low speed break-in period is to allow the metal-to-metal contact points (bushing to shaft and commutator to brush) to wear against each other, removing slight irregularities such as high spots, burrs or sharp edges which may be left from the manufacturing process. If the motor is run at high speed initially, the brushes can bounce on the high spots of the commutator, which can result in arcing and damage to the brushes or commutator.

Many racers attempt to run a motor long enough during break-in to completely seat the full width of the brush. This can take several hours and is not necessary. Often the heat generated during this long break-in damages the commutator or bearings. The result is a slow motor. A long break-in period is especially dangerous for stock motors. The final phase of break-in occurs when the motor is run in a car under load. Under load, the high speed friction and current flowing through the motor brushes actually liquifies the brush contact surface slightly, allowing it to perfectly match the commutator shape. This occurs in just a few minutes of running. Artificially wearing the brushes for 2 or 3 hours does not accomplish this.

MOTOR SPRAY AND OIL

Most electronic contact cleaners are satisfactory for use on motors. Check the label before using a new brand. It should be residue free and safe for plastics. Residue free means that the spray will not leave a film on the commutator that could interfere with electrical conductivity.

Be sure to use high quality oil. If you stick with the name brands you can't go wrong. Oilite bushings require slightly thicker oil, so use 10 to 20 WT for best results. A 5 WT oil works great on ball bearings. Using an oil thicker than necessary will result in excess friction. The resulting drag may cost you a few seconds in run time, or even a little top speed. If you like to experiment, try using synthetic oil. Their finer molecular structure can increase RPM and improve run time, as well as extend bearing life. At TWISTER, we use a 50/50 blend of 20WT Pennzoil and Marvel Mystery Oil on stock motors and straight Marvel Mystery Oil on ball bearing modified motors. Marvel Mystery Oil is available at most hardware and auto parts stores. It is one of the highest quality oils you can buy.

CAPACITORS AND LEAD WIRES

Now that your motor is ready to run, you should install capacitors to prevent ratio interference and to be compatible with auto count scoring systems. Use 3 .1 MFD 50 volt capacitors. Connect one from the positive contact to the can (ground). Connect a second from the negative to the can. The third connects from positive to negative. If you use an electronic speed control, follow the manufacturers recommendations for capacitor installation. Be sure to use a fuse as a shorted motor can blow your speed control.

Use at least 16 gauge lead wire to hook-up your motor and 60/40 or 63/37 solder on all connections. 63/37 solder will survive better in high temperatures, but is a little more difficult to find. When soldering, use a good flux and a hot enough iron to properly melt the solder. A dull looking finish indicates a cold joint, which will restrict the flow of electricity. Use as little solder as possible since solder does not conduct electricity as well as the wire itself. If you really want maximum power, do not use plugs, but instead solder the leads directly. Each plug can lose as much as a tenth of a volt and will cost you run time as well as speed.

MOTOR CLEANING

Before we move on to performance tuning, let's cover the basics of motor cleaning. To clean properly, remove the motor from the car. The motor cannot be cleaned properly while in the car and some motor sprays may even damage the plastic parts of the car. Run the motor on a charger or a power supply at 3 or 4 volts (low speed) or on a 4 cell battery pack. Cleaning while running will prevent dirt from lodging in the bearings or between the commutator segments. First, spray motor cleaner or a good brand of residue-free electronic contact cleaner liberally through each bearing. Then spray the commutator and brushes through the end bell for a few seconds. Allow the motor to run for a minute or two to dry the bearings and commutator. Disconnect the motor and apply a drop of oil to modified motor bearings or several drops of oil to the oilite bushings on a stock motor.

Many manufacturers are selling commutator cleaning tools. Use care as some of these tools are too abrasive and may damage your commutator. A TWISTER Commutator Tool can be used to clean and polish the commutator without fear of damage and will restore lost performance to old motors or keep new motors running their best.

PROPER GEARING

As with real race cars, each car, motor and driver combination will require slightly different tuning to achieve maximum performance. Proper gearing is a critical part of RC car racing and an excellent place to start when tuning your motor for peak performance. All TWISTER MOTORS come with a gear ratio chart to help you find the best gear ratio for your car and motor combination. If you do not have a TWISTER Gear Ratio Chart, call the TWISTER HOTLINE. When in doubt about the best place to start, always use a pinion gear smaller than you think you will need. Starting with a pinion gear that is too large will make the car feel sluggish and cause excessive amperage draw, high heat and premature motor failure. Finding the right gear ratio is very easy once you have established a starting point. Just go up one tooth on the pinion gear each run until the batteries dump too soon or until the car starts getting sluggish off the turns. When this occurs, go back down one tooth on the pinion. You now have the right gear ratio for the track and conditions.

On tracks with shorter straightaways, you can run small pinion gears as top speed becomes less important than acceleration off the turns. For tight, twisty tracks it is best to gear the car for peak performance in the infield section even if you have to sacrifice some speed on the longer straights. Keep in mind when motor tuning that the car that finishes first wins the race, not the car with the highest top speed. Acceleration off the turns is more important than pure top speed.

At this point, you may be asking how to tell if your car is fast or slow. The most important tool you can own in this sport is a stop watch. You must time your car to determine whether or not the changes you make are improving performance. When selecting gear ratios, don't just time complete laps. Divide the track into segments and time the car through different segments of the track. By using this technique, you will truly find the quickest combination for the course.

TIRE SIZE AND GEAR RATIO

Changing tire size can have a dramatic effect on overall gear ratio. A change in tire diameter of 1/8 inch makes a difference of 2 pinion sizes on a 1/12 scale car. You should measure tire size after each run and change pinions if necessary to maintain a constant gear ratio especially if you're using foam tires on asphalt where tire wear is very rapid. Computing the percentage is a fast and simple method of maintaining a relatively stable gear ratio. Example: if the circumference of the drive tires is 10.0 inches before a run, and the tires wear down to a circumference of 9.8 inches after the run, you must run a higher gear ratio to maintain the same overall gearing. To compute the percentage change divide the second measurement by the first. In the example we would divide 9.8 by 10.0 which equals .98. Multiply the gear ratio by this number to determine the change needed for the overall ratio. If you started with a 7.0 to one ratio, multiply 7.0 by .98 which equals 6.86, the new gear ratio you must run to maintain the proper overall ratio.

Don't be alarmed if you can't run the exact same gear ratio as someone else even though you are using the same car and motor. Variations in driving style, tires, bearing condition, batteries, etc. can cause slight variations in gearing. If there is a major difference in gear ratios, look for problems such as frozen bearings, weak batteries or a bad speed control. The motor is usually the first item blamed for a speed problem, but is rarely the actual cause.

MOTOR TIMING

Once you have established the proper gearing, you can fine tune your car's performance even further by experimenting with motor timing. Although you can't mechanically change the timing on stock motors, you can alter the timing by installing timed brushes. We will cover stock motor timing later in the section on brushes.

When you find that you can no longer go up on gearing without the batteries dumping or bogging the motor, but you still have some extra run time, you can use that extra battery power by advancing the motor timing. Advancing the timing will cause the motor to draw more amperage, adding power and decreasing run time. Before altering the timing, put a mark on the motor can adjacent to the end bell notch so that you can return to the factory setting. Never retard the timing from factory settings as this will cause the motor to run hot and greatly reduce its life expectancy. To advance the timing, loosen the two phillips head screws locking the end bell. Rotate the end bell in a counter-clockwise direction, then tighten the screws again.

Advance the timing in 1/16" (5 degree) increments until satisfactory results are achieved. Advancing the timing will relieve a little of the bottom end punch, add power to the mid-range and increase the maximum RPMs.

Sometimes you can go faster by advancing the timing as much as 1/4" (20 degrees) and then use a smaller pinion. The extra timing lets you use a smaller gear, which will allow the car to accelerate off the turns faster. We do not recommend advancing the timing more than 1/4" (20 degrees) as this may greatly decrease the life of the motor.

If you are not sure where you motor is timed, or if the end bell has been moved without first marking on the motor can, the following technique can be used to find the most efficient setting (called the neutral running plane). Connect the motor to a regulated power supply (a normal charger will not work) or a battery pack with an ampmeter in line. Any voltage between 4 and 8.4 volts is OK. Loosen the end bell screws and rotate the end bell clockwise until the ampmeter reads its lowest point. Then rotate the end bell counter-clockwise until the ampmeter and the RPMs just begin to rise. Stop at this point and tighten the end bell screws. This setting will give the best combination of power and efficiency.

BRUSHES AND SPRINGS

By now you should have the right gear ratio and be pretty close on timing. The next place to experiment is with brushes and springs. Since you cannot balance, change timing or rewind stock motors, brushes and springs are the only way to improve performance.

TWISTER modified motors are supplied with #601 hard brushes and extra heavy springs. TWISTER Ultra Stock motors use a very soft brush and extra heavy springs. These brushes and springs are designed to work well in average cars on both street and off-road conditions. They may not be the best for your particular track, car or driving style.

There are three basic brushes: the soft brushes supplied with stock motors, the #602 medium brushes and the #601 hard brush. The soft, stock motor brush should be replaced with #601 or #602 brushes for racing. Modified motors should use the #601 brushes for 10th scale and #602 brushes for 12th scale. The #601 hard brush will give good power and its hard finish will keep the commutator in good condition resulting in long life and low maintenance. The #602 medium brush will draw more amperage, giving a little more torque and RPM and is the fastest brush for 10th and 12th scale stock and 12th scale modified motors. #602 brushes are easily overheated which causes glazing and power loss. When running #602 brushes you should check them after every run.

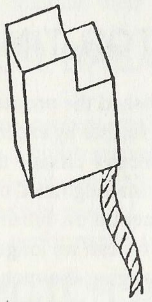

Figure # 1

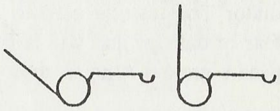

Figure # 2

The end of the brush will be very black and discolored if it has been overheated. #602 brushes should be cleaned and deglazed with a #600 TWISTER Commutator Cleaning Tool after every run and replaced after 5 or 6 runs. This will insure maximum power at all times. Do not use #602 brushes or any other type of soft brush in high RPM 10th scale oval or off-road motors. These brushes will damage the commutator and greatly reduce motor life.

In addition to various degrees of hardness, brushes come in three styles: full size, cut or timed. Full size brushes will give maximum amperage draw and therefore maximum power. Unfortunately they also produce maximum drag, and the least run time. Full size brushes will always give the best power for oval and off-road racing.

Timed brushes are usually only used in stock motors. Timed brushes have the trailing edges reduced. This improves power by shortening the brush overlap period, but also increases the amperage draw giving a little less run time. Timed brushes may be installed backwards to retard timing. This will increase low end torque and extend run time by reducing amperage draw, but it will severely limit top speed. Cut brushes provide lower drag and reduced amperage draw by cutting three sides of the brush. This substantially reduces the contact area and brush overlap period without affecting the timing. Cut brushes give better torque and more run time with only a slight loss in high RPM power. The added torque makes cut brushes excellent for 12th scale carpet racing. Cut brushes should not be used for off-road as the extra torque will cause more tire spin off the turns.

A tuning trick used by the pros is to cut 1/3 to 1/2 off the top of the brush for reduced drag without any timing change (see figure #1). This is especially fast on oval tracks and works on both stock and modified motors. It is easy to modify your own brushes with an emory board (used for finger nails) or a small file; just be sure to cut each brush the same. Cutting the brushes in this manner will give more run time and higher RPM without sacrificing any top speed. These brushes are supplied free with all TWISTER Stock Motors in our PRO STOCK KIT!

After you've selected the proper brushes for your application, you should check the alignment of the brush hoods (holders) on the end bell. To do this, install new brushes and replace the springs, then run the motor for a few seconds (20 to 30). Now remove the brushes and look at the contact area. If the contact area is off center (the armature is not wearing the center of the brush), loosen the screw holding the brush hood and move the holder to align the brush. Re-tighten the screw. Test again. Keep testing until you are certain that the alignment is correct, then solder the screws so that the hoods cannot move. A simple tool for aligning brush hoods can be made by filing a piece of 3/16 square steel stock on one side until it just fits into the brush hood.

Once you have aligned the brush hoods, the brushes should be soldered directly to them. This guarantees maximum electrical conductivity and gives maximum power. Brushes should be replaced anytime they show signs of overheating or damage. They should be replaced every 6 to 12 runs otherwise. The dirtier the racing conditions are, the more often the brushes should be replaced. Dirt imbeds itself into the brushes and scratches the commutator.

Brush springs must also be tuned for best performance. Extra heavy springs are supplied on both TWISTER stock and modified motors. These springs are very stiff to prevent arcing of the brushes and to insure good torque under all conditions. The standard springs should be replaced if you are running 1/12 scale. Since 1/12 scale motors run on smooth tracks and at lower RPMs, they can use the lightweight #609, 90 degree springs (see figure 2). These springs will cut amperage draw and add top speed. The #610 heavy 150 degree springs should be used if you are looking for more speed from your oval motor. Using lighter than stock springs will improve run time and RPM. Going to too light a srping will lose torque and may allow the brushes to bounce and arc on rough tracks or with extremely high RPM motors. As a general rule, use light springs on carpet or asphalt and heavy springs on rough dirt or high RPM motors.

Now that your motor is almost ready, a light tap with a small block of wood on the shaft at each end will properly align and seat the bearings. Always replace noisy bearings. A noisy bearing has been damaged and will slow down your motor. Be careful when tightening end bell screws or motor mounting screws. Over tightening can distort the motor can causing a power loss.

Good equipment, experimentation and practice are the common denominators shared by most winners. We hope the TWISTER MOTOR TUNNG GUIDE will help you to better understand your RC car motor and enable you to tune it to its peak potential.

If you have any questions don't forget the **TWISTER HOTLINE: 818-914-6177** Or write us a letter. We'll be glad to help you get **"THE UNFAIR ADVANTAGE"**.

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