New Motors for Small Civil War Locomotives

Most of the locomotive models suitable for use as Civil War stock would benefit from re-motoring. Almost all were produced with open frame motors that were not very efficient or powerful. In an effort to compensate for these drawbacks, manufacturers often used motors that were too large to fit within the boiler shell. So most were mounted in the tender, necessitating extended couplings to power the drive wheels in the locomotive, an approach that further reduced their efficiency. Fortunately, the development of more effective motors during the last generation means that we can now do much better. Today's more powerful motors are even produced in small enough sizes to fit within the boilers of even the smallest of HO locomotives.

Of course, space even within the tenders of these models is very restricted. The interior of the tender shell of a Gem Wm. Crooks 4-4-0, for example, is only 10mm high, 23 mm wide, and 45mm long (an extra 1mm of height can be gained by resting a motor below the tender deck on the bolsters). The interior of the Mantua General shell, though a little bigger, still only measures 13mm high (11mm if the deck is lowered to prototypical height), 25mm wide, and 48mm long. The shell of the PFM V&T Reno tender is equally small: just 13mm high by 25mm wide and 44mm long. So even if you wish only to change motors within the tenders, you still have to concerned about size.

But there are other factors to consider in selecting a new motor. First, keep in mind that model locomotives, just like their prototypes, have different power requirements: switchers that creep along with a few cars, freight locos that drag, long heavy trains, and passenger engines that speed along with light cars all vary in their needs. A fast motor with a low stall current (the current in amps beyond which it will overheat) might be fine for a passenger engine, but freight power needs a slower motor that can tolerate a higher stall current (generally speaking, small motors should not be run at more than 1/3 the stall current rating). How you operate trains matters, too. If you like to watch trains run continuously around a circular layout hour after hour, you need a more rugged motor that can handle heat build-up than if you do a lot of stop and go switching, allowing motor heat to dissipate while you work switches and uncouple cars. Whether you plan to run engines with or without DCC and how much amperage your control system handles introduce still other factors. And then how much you are willing to spend, either in money or time spent on installation, adds to the equation. So, there is probably no one motor for all applications, much less all modelers.

Let me illustrate some of these issues with regard to re-motoring what is and has long been the most common model of a Civil War model—the Mantua General. These were originally produced with an open frame motor in the tender that Mantua made itself, probably based on a design of Pitman, once America's leading producer of small hobby motors. Forty years ago these brushed motors, which had five poles to their armatures rather than the three poles common in cheaper versions were pretty good; but like all iron cored motors with non-skewed armatures, they suffered from "cogging" or a hesitation that occurred at certain points as their armatures turned. So they needed a lot of voltage to start, began to turn only at a relatively high voltage, and then dissipated power as heat, particularly as they sped up or came under a heavy load. They got so hot after running for awhile that it hurt to touch them with bare fingers.

Realizing these limits, Mantua switched to improved "can" motors near the end of its corporate existence. These are still brushed motors with armatures. But they are popularly designated can motors because many are contained in cylindrical coverings. A round, can-like covering, however, is not their distinguishing feature. Some, in fact, are made with flattened sides—and thus called flat can motors. And a few of the smaller ones may even lack any such encasing. What really distinguishes them from older motors is that they have permanently magnetized plates around the armature instead of a rear magnet, skewed armature poles, and are usually made of materials other than iron to produce stronger magnetic fields. These design changes reduce cogging considerably and make them more efficient than the old open frame motors. They start at a lower voltage, turn more smoothly at slow speeds, waste less power as heat, and so have more torque or turning force for a given current in amps. And this in turn means they can be made smaller than older motors while still remaining more effective.

Mantua's can motors, which were designed to fit into the General's tender with no modification, are unfortunately no longer made. But there are plenty of other can motors that can be used in their place. These run the gamut from inexpensive CD/DVD 12 volt DC motors available on eBay to the far more costly brands sold by Japanese and European firms. Prices vary because of differing quality. Higher quality motors are more effective and longer lasting. The more poles, the more accurate skewing of the armatures, the better quality of the windings and bearings, the more efficient their operation and the less likely they are to fail from heavy use or overheating. The nature of the magnets used is also very important. Motors made with rare earth magnets such as Samarium Cobalt or Neodymium are two or three times more powerful than those made of Alnico. They produce a more powerful turning force or torque while drawing less of a current load in amps. So a higher quality small motor that needs fewer amps can outperform a bigger but more cheaply made one.

Size incidentally, is usually expressed in millimeters, and motors are often designated by two numbers, their diameter (or narrower side) and their length. So a 1220 motor would be12mm wide and 20 mm long. Today you can buy can motors as small as 8mm in diameter. Still, it is always best to use as large a motor as you can. Primarily this is because the bigger they are the more robust and powerful they are. But there is a related consideration: small motors have lower current limits and so are often made to run on 6-8 volts, requiring the use of resistors when used with 12 or more volts. Given the size of the General's tender, a 12 volt DC motor in the range of 10mm to 13mm in diameter and 20mm to 24mm in length (leaving room for decoders and other accessories) should be about right. Yet another aspect of size to keep in mind is the diameter of the shaft: the largest selection of flywheels, gear heads, and gears are made to fit 1.5mm shafts. So look for one of that size—and be aware that motors usually can be had with shafts at either one or both ends to facilitate their use with f flywheels, gear heads, etc.

As far as quality is concerned, Mabuchi can motors, generally now made in China though sold under a Japanese name, are probably at the lower end of the spectrum. A Mabuchi FF-050SB-09250, which measures 12mm by 24mm and is rated as 9700 rpm at full 11.5 V, sells for $5-$10. What seem to be unnamed versions of these are commonly available from an eBay dealer for $8.00. Japanese Mashima motors are a bit better made. A Mashima FM 1224, rated at 12000 rpm at full 12V, costs $20-$30. Better yet are the European made Maxon and Portescap motors. A Swiss Maxon RE 12 (103709699) motor rated at 10,700 rpm sold for about $30-$35.00. But its production has ceased, so you have to use the smaller RE 10 (118400), a 10mm by 25 mm can motor rated at 12,500 rpm, or the newer A-Max 12 series, both of which cost more. Portescap also lacks a 12mm size, and other than its 8mm series of 6 volt motors, the only option it offers is its 13mm series. A Portescap 13N88 110 1, which measures 13mm by 28.2mm and is rated at

12400 rpm at no load, might work, but it's a relatively big motor for this application and will cost about $80.00.

As good as these motors are, they are not the last word in micro motor technology. That place goes to what are called coreless or brushless motors. These have neither an armature nor brushes. Instead, they are built with a thin wire mesh that spins around the outside of a central magnet. Producing little friction and no cogging, this design yields a smoother, more constant, and stronger action. Maxon makes a coreless EC series of small motors, but Portescap and Faulhaber are generally deemed superior. And their cost reflects it. The Falhauber 122412S, which is a round coreless 12V motor, 12mm in diameter and 24mm long, that runs at 12000 rpm, sells for $70-$100. And Portescaps smallest counterpart, the 13 BC E, a 10 volt motor measuring 13mm by 28 mm and rated at 9300 rpm at no load, lists at $120. Without question these are far more efficient and powerful motors. But they have to be used with great care. Lacking a metal armature to help dissipate heat when overloaded or run at higher than recommended voltage, they can be easily damaged through misuse. And they are not a good choice if you operate with pulsed power or DCC systems that generate control pulses, because this too causes them to quickly overheat (though the new "supersonic" or high frequency, silent running DCC decoders are said to overcome this problem with some loss of torque). Whether the benefits of coreless motors outweigh their costs is for each person to decide on their own. My own preference for the General would be to use one of the more rugged, top of the line brushed motors.

Note that all of these small motors run at relatively high rpms for models whose prototypes ran at about 10-35 mph. To keep models equipped with such fast motors running at plausible scale speeds, they have to be operated at the lower end of their rated voltage, either by manually keeping them throttled back or programming a DCC decoder to do so. This not only reduces the range of speed control, but keeps their torque down—it increases with the voltage too. 5000-7000 rpm would be a better speed. One way to approach this is to equip such motors with reduction gear heads of about 4:1. These are sold by most of their manufacturers to fit over the shafts of their products. And while they do increase the cost about $20-$30, they really improve performance markedly, allowing motors to run closer to their full power potential while propelling models at more realistic speeds. Another useful accessory is a flywheel. Our models of Americans and Moguls have short wheel bases and generally limited electrical pick-up, so they tend to stall easily over dead frogs and on dirty rail. Flywheels, which keep a motor turning for a few seconds after a loss of power, helps them to overcome this problem. And as Northwest Short Line sells small flywheels for 1.5 mm shafts in the $3-$5 range, they are not a big expense. On the other hand, fabricating all wheel pick-up on the tender trucks might be a better way to address this problem than trying to crowd a flywheel into the tender shell.

How actually to install any of these motors in the tender of a General or how to devise a drive train to the locomotive goes beyond the scope of this discussion. There are many Internet sites offering tutorials on motor installations in specific steam engines, and there is a Yahoo Group expressly dedicated to the discussion of all the different aspects of re-powering and re-gearing (http://groups.yahoo.com/group/repowerandregear/). Besides providing guidance on installation, these sites will also offer suggestions on where to obtain motors and other supplies for most re-powering needs.

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