COMBAT ZONE

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BUILD REPORT

Increasing the Speed and Power of a Combat Robot

● by Pete Smith

I wrote an article for the November '06 issue of *SERVO* describing how to convert a cheap cordless drill into a drive motor for a smaller robot. I used two of these in my 12 lb combat robot "CheepShot 3.0." They have proved very reliable but for the last year or so I have been looking for replacements that would increase both speed and power.

I looked at replacing just the motors but could find nothing that had a sufficiently high rpm per volt (Kv) rating and be able to operate at the voltage and current ratings of my speed controller. Another possibility would have been to use a pair of new gear motors from Banebots. These are available with gear ratios and motors that would give me what I wanted but would have required new wheels and hubs and considerable redesign work inside the chassis. They also cost quite a bit more than the existing gearboxes.

A possible solution came when I spotted an advertisement for a 24V cordless drill at a local auto supply store. The drills were only $20 each after rebate so they certainly met my cost requirements. They have a speed 700 sized motor and a two speed gearbox. The top speed of 1,140 rpm would give extra speed over the typical 500-900 rpm of the smaller drills, and the bigger motor would greatly increase the available power.

The main question remaining

FIGURE 1

was whether or not they were easily modified to be suitable as a robot drive train. To answer this, I bought one and stripped it down.

The drill used in this article is the Power Craft Pro CDD24 (**Figure 1**) which comes with a 24V battery, a charger, plus some assorted drill and screwdriver bits. A search online revealed that the same drill is offered by several different companies under different model numbers.

The first thing to do is to put the battery on to charge as per the manufacturer's instructions.

We'll need to remove the chuck (**Figure 2**) before disassembling the rest of the drill. The chuck is locked in place by a small, left-hand thread screw inside the chuck itself (see **Figure 3**). If you're lucky, you can remove this just using a screwdriver (remember to turn clockwise to loosen a left-hand thread), but they are usually too tight.

There are two methods which will work. The first is to use another drill to start drilling out the screw. The heat and torque applied by the drill bit will loosen the screw and it will come out rather than be bored out by the drill. The downside of this approach is that you need a second drill and that the screw itself will be damaged. The second method — and the one that I use — is to get an "impact driver." The driver must be able to loosen or tighten screws (many of the cheaper ones only loosen right-hand threaded screws and will only make the left-hand threaded screw tighter). A McMaster Carr part 5610A2 (**www.mc master.com**) will do the job.

I needed to use a 1/4" socket and an extension piece to get it to be able to reach the screw (**Figure 4**). Set the driver to turn clockwise and with the chuck held securely in a vice, give the back of the driver a sharp tap (or two) with a hammer and the screw will be loose enough to easily remove. **Keep the screw for later use.**

I would advise the use of safety glasses and an absence of spectators for the next step.

The chuck is threaded onto the gearbox using a conventional right-hand thread. This will usually be too tight to remove by hand but there is an easy way to remove it. Fit the newly charged battery to the drill and place a large hex key or similar (**Figure 5**) in the chuck. Set the drill in reverse, spin it up, and then allow the end of the hex key to strike a solid object (like a vice or workbench). The shock will loosen the chuck and it will come off easily.

There are two screws on the front face of the drill under which the chuck is attached (**Figure 6**). Take out these screws and the adjustable torque mechanism can be removed. Next, remove the screws that hold the two halves of the drill case together and lift off the top half. The motor and gearbox (**Figure 7**) can then be lifted out of the other half of the case. **Keep the two halves of the case** as we will use them later.

The gearbox has a lever mechanism on the exterior that is used to change the speeds. This is shown in the high speed position in **Figure 7**. The gear ratio was established by marking one blade of the fan on the motor and also marking the out-put shaft. By counting how many turns of the motor is equal to one turn of the output shaft, I found the fast speed ratio is 15:1 and the slow speed is 45:1. The motor is attached to the gearbox using a "bayonet" type catch and can be easily removed.

The gearbox has all metal teeth and the output shaft is essentially the same as the one on the smaller drills, so will match the existing chassis on the robot and the hubs on the wheels. The motor has a standard 5 mm shaft and a large internal fan that should help keep it cool. Motor timing appears to be neutrally timed so that it goes the same speed in either direction. This is important as in most applications the motors will be turning in opposite directions on each side of the

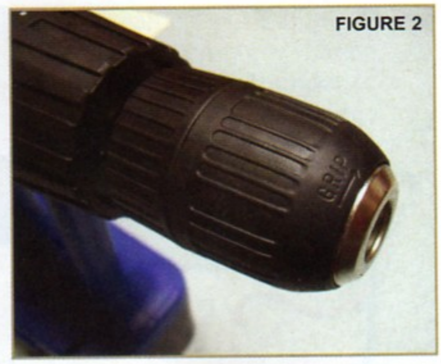
FIGURE 2

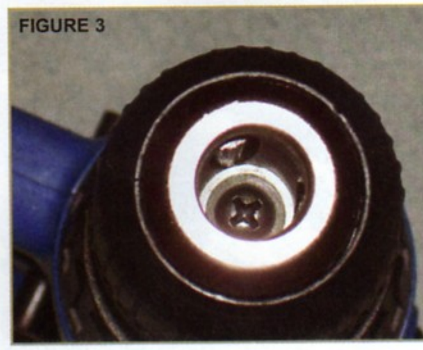
FIGURE 3

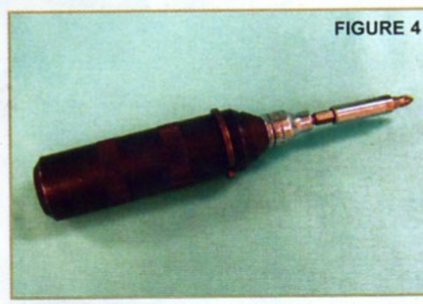
FIGURE 4

FIGURE 5

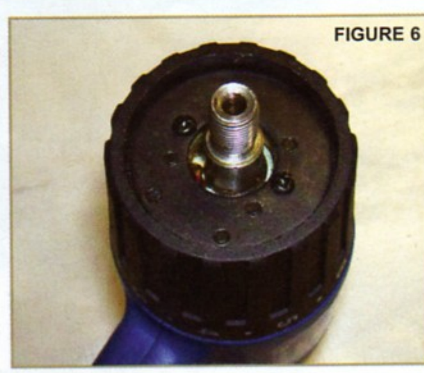
FIGURE 6

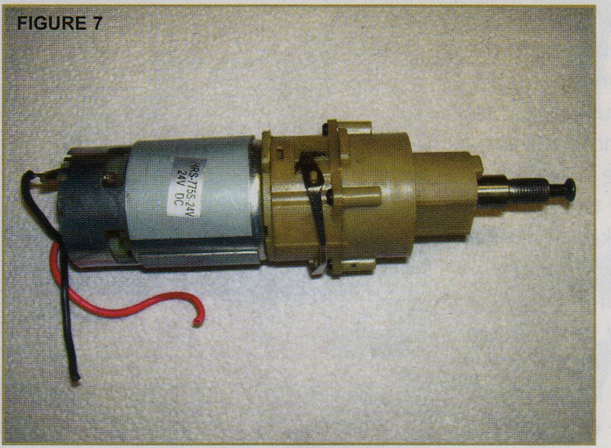

FIGURE 7

robot. If the motors have advanced or retarded timing, then the bot will tend to pull to one side when you try to drive in a straight line.

The first problem to overcome is that of locking the gearbox in the required speed (1,140 rpm, in my case). You could do this by simply taping or heat shrinking the lever shown in **Figure 7** in the required position. This would probably do for most applications but the parts and mounting pins are pretty flimsy and perhaps would not stand up well to the forces involved in combat robotics.

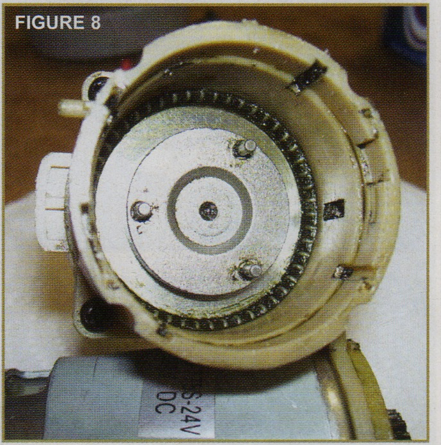

FIGURE 8

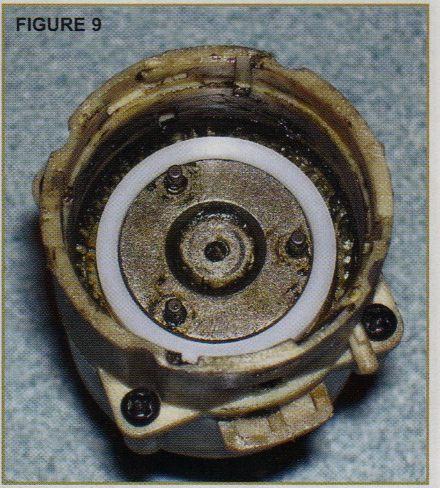

FIGURE 9

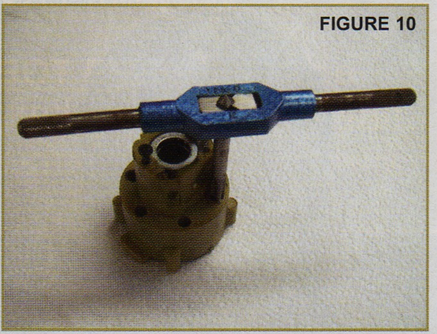

FIGURE 10

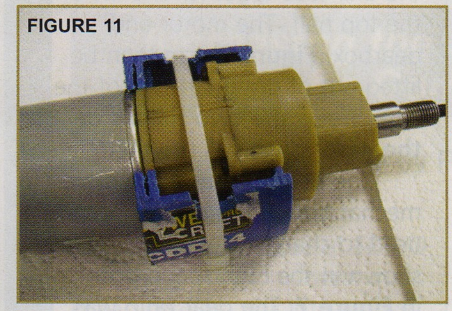

FIGURE 11

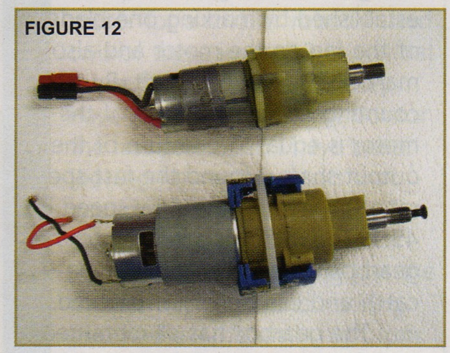

FIGURE 12

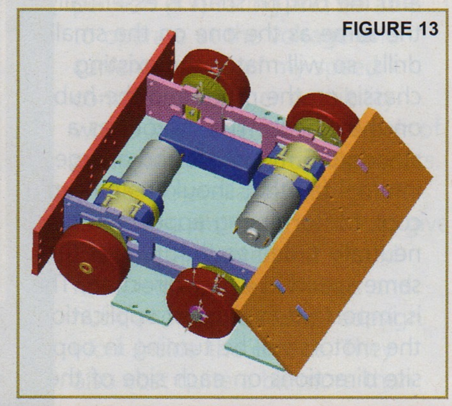

FIGURE 13

Progressive disassembly of the gearbox showed that the external lever moved one of the ring gears so that it is either locked or free to move. In the low gear position, it is free to turn and activates the midd set of 3:1 planetary gears and thus increases the overall gearing. To lo the gearbox in a 15:1 ratio, it is necessary to add a spacer behind this moving ring gear.

First, remove the external lever and pull out the ring gear. Also, remove also the three small planetary gears until only their carrier remains (**Figure 8**). I made a small spacer ring out of nylon on my lathe. The ring has an external diameter of 1.25'', an internal diameter of 1.030", and is 0.150" thick. This part is then placed over the carrier (**Figure 9**) and then the gearbox is reassembled.

It should be similarly possible t lock it in "low" speed by adding a spacer to the front side of the ring gear instead but this would have required a differently sized part an I have not tried this.

There are six openings around the front face of the gearbox. The are used by the torque adjustment mechanism and we will now use them to lock the outer ring of the final stage of the gearbox. The outer ring of the gearbox has a series of bumps around one end. I you look into the holes at the end of the gearbox and slowly rotate t shaft, you can see them pass by.

To allow the gearbox to transmit power from the motor to the output shaft, it is necessary to stop the outer ring from moving. This is done by adding M6 x 8 mm setscrews into a couple of the openings. The setscrews will self-ta into the holes, but I actually tappe the holes as shown in **Figure 10**. You should ensure that they enga the gaps between the bumps on the outer ring. Do not over-tighte the screws as you are likely to distort the gearbox and cause premature wear or failure. All tha is required is that the outer ring is stopped from rotating.

Now that you have the gearbox locked in "high" and have disabled the torque mechanism, you can refit the motor to the gearbox. **Do not be tempted to run the motor yet.** It is necessary to add something that will lock the gearbox to the motor. Failure to do so will result in gears flying in all directions (guess how I know this!). In the original drill, the case performs this function and tabs on the gearbox fit into slots in the case. A couple of minute's work with a hacksaw cut the relevant sections out of the case (**Figure 11**). These can be secured in position with a simple tie wrap.

The complete motor and gearbox can be seen in **Figure 12** next to one of the smaller originals. It weighs 1.4 lbs (0.4 lbs heavier) and the assembly is considerably longer so that needs to be taken into account in your design. The 3D solid models can be found in the "Solid Models" section of my website at **www.teamrollingthunder.com**. You can get hubs for the popular Colson wheels that fit directly onto the shafts from **www.kitbots.com** and these are secured by the left-hand threaded screw. **Figure 13** shows how the new motors will fit into the existing CheepShot 3.0 chassis. **SV**

Photographs by Peter Smith.

MANUFACTURING: Modular Design in Combat Robotics

● by Blake Hooper

In combat robotics, modular design can be a safe approach to dealing with both damage and changing circumstances in the arena. The basic principle works by separating the main components of your combat bot into multiple, independent assemblies. Once all of these modules are completed, you can assemble the entire bot quickly and swap out the modules easily for repair or replacement by a better component. In situations where your motor burns out or your weapon assembly is destroyed, having a back-up module will end up extending your bot's life. Like any type of design, however, there are advantages and disadvantages to using this method.

What's Good and Not So Good

To begin with, there is a great advantage in design flexibility. Immediately, you will be able to broaden your design options from the weapon type to armor placement. This also means having a flexible strategy during matches. Depending on your opponent, your weapon type might not be good enough necessitating a change, or you might need to completely rearrange where the armor is focused. Finally, one of the minor advantages is the ability to build in stages. Instead of working from scratch, you can construct one assembly at a time, finishing different aspects of your bot independently. Many builders will leave projects unfinished, citing one incomplete part or another as the reason for not finishing their bot. Using a modular design, they could still enter competition, filling in the unfinished component