

The Electric Trials Bike (ETB)

The idea for an electric trials bike finally turned to action in 2006. After thinking about it for a few months, I decided to act. It seemed to me that a trials bike might be the optimum electric motorcycle application. After all, a DC motor has maximum torque at zero rpm, great for trials. And batteries tend to recover somewhat when you use them heavily, and then don't use them for a few minutes (riding to a section, getting off and walking the section). Plus there is new equipment available that makes the whole task much simpler than it would have been a few years ago. And that will only get better with time, as new technology batteries finally come to market, and the market acceptance drives the manufacturing costs down as they are made in the thousands or even millions.

Many might be familiar with the Denali Trials bike which I believe was first available around 2000. It seems there was little interest in this bike, and now Electricross is making the Drift, which has many similar characteristics, but has been made for motocrossing. Both these bikes utilize custom lightweight frames, and would appear to be electrified bicycles adapted for motorcycling application. This is not a criticism, I applaud their efforts. Out of every good idea come more ideas, heck even out of bad ideas you can get forward progress (I speak here from a little bit of experience). You try something, and if it doesn't work, you adapt it and try again.

When I first mentioned to Adrian that I was going to build an electric trials bike, he advised me to forget it, Honda had tried several years ago and had not succeeded. If they failed, what chance would I have. But once I make up my mind about something, I can be pretty persistent. So after thinking through everything, I finally decided to find another Montesa 2000 315R. I have been campaigning a 315R for the last couple of years, and I thought if everything went completely wrong, at least I'd have a bunch of spare parts.

In June, at the Cowpile trial, I was asking Adrian if he knew of a 2000 315R for sale, when by sheer coincidence, Steve Monighan decided to sell his Montesa and get a Gas Gas 200, like the one his son Evan was riding. Adrian graciously offered to step out of the deal and Steve sold me his bike directly.

So over the next few weeks I started measuring and trying to figure out where I was going to put everything that was required. I had stopped by my local electric motorcycle fabber and discussed my ideas with him. He had most of the parts I was going to need, so I got a price list, and some dimensions, and a few ideas to boot. He was expecting some new motors to arrive, and that turned out to be a long wait. In the mean time I had cut out some foam in the dimensions of the various larger bits, (motor, controller, and four 12v batteries). As it turns out, this is a LOT of equipment to find space for in the sparsest motorcycle design.

When I thought I had a rough idea of how things could come together, I started dismantling the “test mule”. My initial plan was to build a bike that was functional, as a proof of concept. For this design I opted for a one gear, constant mesh configuration. To get the gearing down to approximately 2nd of the 315R I incorporated a jack shaft that would allow a near 2-1 ratio from motor to countershaft. The standard gear reduction from countershaft to rear wheel is another 4-1, giving an overall 8-1 ratio.

So I removed the gas tank, the engine/transmission, the muffler, the radiator, the airbox and carburetor. I had weighed the bike before starting, and it was right on the spec, 168 pounds, perfectly balanced with 83 pound on each wheel. I had also taken my original 315R to a Harley shop and run it in the dyno. The engine has an interesting HP and torque curve, starting out high and finishing lower. But peak HP was around 14, and peak torque was around 16 ft lbs. I weighed the remaining chassis and wheels (without rear fender and chain, and it weighed 95 lbs, so I had about a 75 pound weight budget.

Some quick calculations indicated I might be in the ball park. The combined weight of the motor, controller, and the four 12v batteries was about 75 lbs. As I found out later, the miscellaneous bits I added (motor mounts, battery mounts, shaft, sprockets, chains, wires, cables, lugs, throttle assembly, computer) added almost another 30 lbs. But I don't want to get ahead of myself, the story continues.

I purchased some scrap aluminum that I believed would cover all the new parts I had to make. Of first concern was the motor mount. I had a rudimentary design in mind and started cutting and fitting parts. By this time, the motors had finally arrived so I purchased the motor, controller, throttle assembly, batteries, computer, wiring and heavy duty lugs I would need for the build. Now that I could take good measurements, the fabbing went on in earnest, often going to midnight in the garage. But I was having so much fun I could hardly believe it.

I contacted a friend of mine who is an excellent welder and asked him if he could weld the aluminum bits for me. He declined, saying he could weld steel, but not aluminum. But he recommended a guy in Concord. Then by sheer happenstance, I discovered the Vince at V-Mar was an aluminum welder. Plus Vince is a trials rider, and makes lots of really nice parts for trials bikes. Having Vince's input turned out to be invaluable.

When I had fabbed all the individual pieces, I took them to Vince for welding. He got the job done in between everything else he has going on, so I had to be a little patient. But I finally got all the parts back and started assembling the test

mule. There was one mistake I made at this point. I was nervous about the motor to jack shaft chain, inviting a toe or finger to be nipped off. So I built a shield that fit between the two sprockets. Where I chose to drill the mounting holes could not have been worse, as I soon found out.

So finally the bike was assembled. I had rewired a switch to provide on/off power to the controller and a low power switch which would cut output from the controller in half. I thought this would be useful in a trials application. The switch also now sports a red LED for power on, and a blue LED for half power indication.

One mistake I made as I wired the unit is I got the terminals confused on the controller. It is upside down where the radiator would normally be. So after I discovered there wiring error, I was very pleased to find the blink codes on the controller indicated all was well as I turned on the power switch. As I turned on the power and rolled on the throttle, (with minimal settings on the controller) the rear wheel started to slowly turn . I had set the controller to half power with a linear throttle response and as I rode it for the first time, it was thrilling to find the bike actually rideable. But as I soon found out, doing wheelies was a problem. Small wheelies are a definite requirement, even for the easier lines in a section, so this caused some immediate concern.

What had gone wrong? Was the controller behaving properly? I upped the output settings, with similar result. Did I miscalculate the gearing? The bike had a top speed of around 20 mph, so that was pretty close to expected. Was there something wrong with the motor, were the batteries properly charged and performing as expected? As I continued to ride and try to pull a decent wheelie, all of a sudden the bike stopped after a nasty sounding crunching. I looked down and both chains had fallen off. What the ..??

It turns out I had bent the motor mounting frame. Two screws (for the shield I had mentioned earlier) right at the point of maximum pressure on the frame. Stupid, stupid, stupid. So I pulled everything apart and removed the now disfigured frame. I went back to Vince and we discussed whether anything was salvageable. Then Vince came up with a brilliant idea that really simplified the design and it would be much stronger, and also was a very esthetic design. As I thought more about it, we came up with a similar design on the opposite side. But Vince was very busy again, so again I had to exercise some patience.

When I got the parts and reassembled the bike, it looked great. I had fully charged the battery, and was hoping for better performance. However, the performance was much the same as before. So I took the bike down to the shop where we trouble shot the problem. By hooking another bikes battery set in parallel to the trials bikes, we were able to see that the controller and motor where able to pull almost 300 amps. The bike by itself could only pull around 140 amps. So we looked at each of the batteries and found one that was no good.

Murphy's law is alive and well. Of course the bad battery was the one that was the most difficult to remove. Unfortunately, none in stock, so I had to wait a few weeks for a new order to arrive.

So once again, all back together, another test, similar result. I called the shop and discussed the issue, and was told that these batteries need to be cycled a few times. That means charge them up, discharge them, charge them up, So I put them through several cycles (at one point, I reversed the sprockets on the motor and jack shaft to really force the batteries to work. This resulted in an overall 2-1 ratio in place of the 8-1 ratio). This caused the motor to warm up a bit (normally the motor was never even warm), but I did record a 350 amp draw at one point.

I also purchased a microprocessor controlled battery charger. While a bit more expensive, this charger would charge the batteries the best. One more test in the driveway and private road revealed the bike now had a capability to wheelie properly, at least a low speeds. In fact, from 0 mph is the easiest to lift the front wheel. I should point out at this point that the completed "test mule" is heavy, 195 lbs, and the front end at 102 lbs. is heavier than the rear at 93 lbs. It also top heavy.

So I called the Lewis's to find out when they were riding again. It turned out that the following weekend several people were going to Frank Raines, So I packed up both bikes and went. There was quite a bit of interest from the trials riders in the club, coupled with a little incredulity. At home, I was able to ride the bike for about 30 minutes on a charge. The harder it is ridden, the shorter the riding time. So I intentionally rode very slowly. As it turned out, it wasn't very muddy, which was a good thing because at this point in time the motor is still unshrouded. I intend to build a shroud that will allow me to ride through water and mud without compromising the motor. This is a future task.

The controller throttle map has a step up just at initial throttle that makes the bike very sensitive in low speed use. I would say almost unridable, but you do get used to the throttle after riding for awhile. Fortunately, the half speed switch makes this not much of an issue. I was able to do low speed on-the-lock turns in half speed mode. And the bike has a great feature for some riders, you cannot kill the engine in a section. It stops, but give it some throttle and off she goes. And the traction is pretty good.

There is one battery down low and rearwards (behind the rear shock), one nestled between the frame where the gas tank normally goes, and two sitting on a board on top of the frame that holds the gas tank. This is a lot of weight forward and up high. I am currently working on a modification to take the topmost battery and move it behind the rearmost battery. I hope this does a lot for the balance of the bike, and makes it less top heavy, although the overall weight will stay pretty much the same.

After riding at Frank Raines (in the dirt) I am convinced that this is not a pipedream. I think the bike has some promise. Riding over logs, the rear wheel was spinning slightly from the application of throttle, but this may be attributable to the step in the throttle profile.

I took it out to Frank Raines for a second try. I had switched the throttle mapping to a progressive setting. There is no step just off the throttle stop, and the bike is far more manageable at low speeds. In fact, the low speed switch doesn't allow wheelies, but it gives even more control at crawling speeds. I rode most of the day in the full power setting, and I am getting used to the action of the throttle. I am able to do full lock turns, although I will admit it is a little jerky. It is amazing how much control a clutch adds to the equation.

Almost everyone who has ridden the bike thinks it is interesting. Some like it a lot more than others, which is to be expected. It makes no sound other than chain noise (kind of a loud ZZZZZZing noise. In fact, charging the bike out in the boonies makes more noise than riding it (the generator, even the Honda, makes some noise). It takes a little less than an hour to charge up to 80% of full charge. (It takes overnight to get to 100%).

What's next? I am working on both rearranging the batteries, and the shroud for the motor. To accomplish both of those, I need to remake the mounting frames. Everything, and I do mean EVERYTHING, is a very tight fit. Once these have been done, I believe I will have a bike I can ride in Saturday events. I will probably start out on the 2 line and see how it goes. If it goes well, maybe I can try the 1 line (which is what I ride with the 315R gas powered bike).

After that, trying a transmission with a clutch, and lithium-ion batteries. These are both serious undertakings, and will require practically a total remake to accomplish. I have found the battery technology I want to use. Now it is a question of convincing the company to sell me battery cells that I can fabricate into the right configuration for the application. These batteries may not be available to the general public for a year or two. I believe the clutch will be great for control, and absolutely required for more accomplished trials riders. The multi-speed will help, I believe, with battery life, especially riding between sections. The batteries will also need to be quick replace (or quick charge) in order to be of use in a real trial. I have ideas on that front also.

I have been toying with lots of names for the bike. ETB (electric trials bike) is descriptive and short, so it might stick, but I also have thought about the "No-Stroke" (as opposed to 2 stroke and 4 stroke) and finally, my favorite - "Eco-Trials".

With the extremely tight packaging requirements of a trials frame, I may ultimately have to build my own frame, but I will know that after I have configured

lithium-ion batteries and see how big and bulky they are. In the mean-time I'm always thinking about improvements. Some will get developed, some won't, at least for a while.

Some one suggested I build kits that allow others to convert their existing bikes. That may be a possibility, but right now I'm really glad I started with the Montesa. It seems to have more room to play with that the GasGas frame.

More later.