PREVENTING MOTOR FAILURES

By
Bob Batson
Electric Vehicles of America, Inc.

In the last few months, EVA and the motor manufacturers have become very concerned with motors and the increase in failures. First, EV motors are seeing harder duty. There is no question about that. They start up more often, see higher amperages, and are often in a bad environment. In stationery applications, these conditions can be controlled. In an EV, nothing is constant. The voltage changes, the amperage is always fluctuating, and the weather conditions (thermal, moisture, heat capacity, etc.) can be detrimental.

Lead acid batteries had the benefit of limiting current; they just could not keep up with many modern controllers. Now lithium batteries have greater capacity. Many can sustain 3x AH rating and peak at 5xAH rating. That means that a 200 AH pack can peak at 1000 battery amps. With current multiplication, the motor amps can be almost 2000 amps!

One customer just wrote me that he failed his 9 inch motor. He had bought a 144V system but upgraded to 300V lithium pack and a Zilla 2K controller. Although he said he limited the voltage and current, the spikes by the controller were catastrophic for the motor!

Unlike the controller which has built-in protection (i.e. max current, undervoltage, thermal cutback, acceleration ramp, etc.), the motor typically only has a thermal switch which actuates upon high temperature. A simple alarm that is often ignored. The motor tries to perform no matter what; even if it means self-destruction.

The predominant failure modes in order of significance are:

- *Excess Amps*
- *High RPM*
- *High Temperature*
- *Motor stalling*

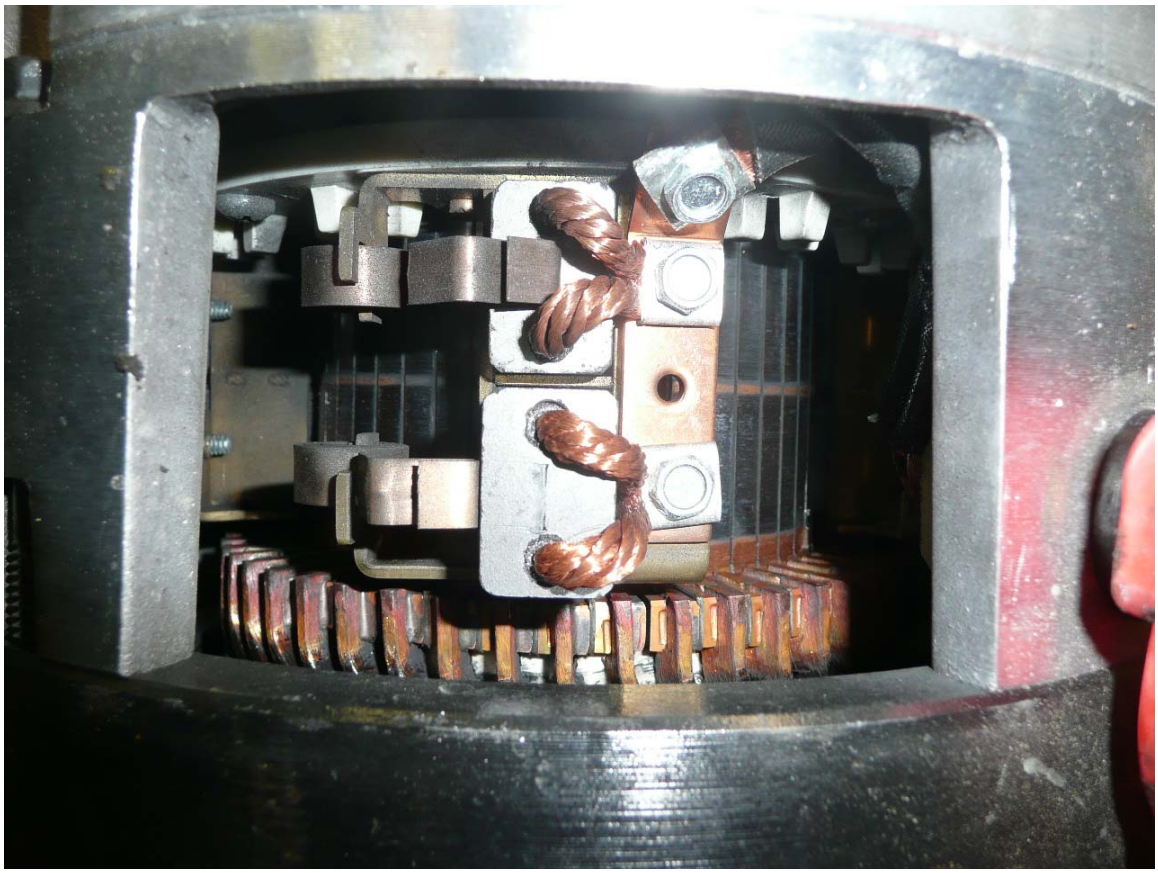
Excess Amps

Most motors are rated at 150-225 amps continuous; however, most controllers are rated at 500 amps, 1000 amps, and 2000 amps max. These are spikes that the motor receives from the controller. A pulse width modulated controller may be operating at a 20% duty cycle. During acceleration, the controller may be "on" 20% of the time and "off " 80% of the time. The 20% may be high voltages and currents. Or it could be an 80% duty cycle with higher average current.

Years ago, EVA recommended an ***Inductive Coil*** *on motors because it averages the voltage and currents. If the controller is operating at 15,000 cycles per second, even 20 percent is 3000 cycles/ second of high current and voltage.*

High voltage and currents typically cause the insulation to break down. This will cause the armature to fail or the armature or field to short to the frame of the motor.

Examples of high currents occurring are when you are climbing a long grade, accelerating, or just simply going too fast. Most lead acid EV can sustain 50-55 mph continuously. Going to higher speeds requires increased amperage and have to potential of burning the armature. The armature will become black vs brown. Tab 2 of the EVA Conversion Notebook provides motor curves and data relating to continuous hp, amps, etc. for your motor. Motor curves are also available at ***our website.***



High Current has blackened armature;
thermal stresses forced brush spring to side of brush.

The key is buying the best motor and system for the specific application and system. Occasionally, customers will try to buy too small a motor. This is one reason, we do not sell on-line. At EVA, we want to talk with the customer to ensure the use of the right components.

High RPM

Failure by High RPM is rare but does happen. Most motors are designed to operate efficiently at 4000-5500 rpm. The point of maximum efficiency varies with actual motor voltage. Failures typically occur when the driver is in the wrong gear (i.e. 1st gear at 45 mph going downhill) or when the vehicle is left in gear when towing. Section 6 of Tab 1 of our Conversion Notebook identifies how to calculate the max speed in each gear. If you need assistance, simply email me.

In addition, one can use a tachometer. The NetGain Motors have a special tachometer that can be used. The speed sensor is available from ***www.rechargecar.com***

Whether you use a tachometer or calculate the max speed for each gear using our equations, it is critical that you identify these parameters on your dash in case someone else borrows your EV.

High Temperature

High temperature can be caused by excess amps, inadequate cooling (lack of air supply), or inefficiency (low rpm). An infrared thermometer is an indispensable tool for measuring the temperature of the motor, controller, contactors, and batteries. You can also us temperature strips that will fasten to components and indicate temperatures. These strips are about $10 for 10 strips. On example is ***Click Here.***

Larger motors have a thermal switch embedded in the field coils. This switch is normally open and will close when the temperature reaches ~360F. You can wire the switch in series with a backup alarm and the 12V battery. This will alarm, so you can slow down or run in neutral to allow the internal fan to provide cooling.

We recommend that you connect the motor alarm to a 12V back-up alarm signal to make noise, so that it will receive your immediate attention. Also use temp strips or an infrared thermometer so that you know what is normal for your application.

Motor Stalling

This condition occurs when the driver uses the motor to maintain the EV on a hill instead of the brake by applying current. The problem is that current is applied while the motor is stalled so all of the energy and heat is going to only to a few commutator bars. This will raise the bar by thermal expansion and cause the insulation between the bars to separate and break away. Once this occurs, you will hear a clicking as the brushes move over the raised commutator bars.

We recommend that you never use the motor as a brake.

Conclusion

My experience is that ~1% of all motors fail due to manufacturing; most failures are customer related damage. Many of our motors have been in service 15 years and more.

Unfortunately, motor failures will probably become greater with the increased demand for higher speeds and voltages and the use of lithium batteries. Lithium batteries can sustain higher currents for much longer times than lead acid batteries. ***So we encourage you to use your instrumentation and drive conservatively.***

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