MOTOR HEATING AND POWER SUPPLY VOLTAGE

There are two major causes of motor heating; copper losses and iron losses. Copper losses are the easiest to understand; this is the heat generated by current passing through a resistance, as in the current passing through the motor's winding resistance. Often this referred to as " I squared R" dissipation. This cause of motor heating is at a maximum when the motor is stopped and rapidly diminishes as the motor speeds up since the inductive current is inversely proportional to speed.

Eddy current and hysteresis heating are collectively called iron losses. The former induces currents in the iron of the motor while the latter is caused by the re-alignment of the magnetic domains in the iron. You can think of this as a "friction heating" as the magnetic dipoles in the iron switch back and forth. Either way, both cause bulk heating of the motor. Iron losses are a function of AC current and therefore the power supply voltage.

As shown earlier, motor output power is proportional to power supply voltage, doubling the voltage doubles the output power. However, iron losses outpace motor power by increasing non-linearly with increasing power supply voltage. Eventually the point is reached where the iron losses are so great that the motor cannot dissipate the heat generated. In a way this is natures' way of keeping someone from getting 500 hp from a size 23 motor by using a 10,000 volt power supply.

At this point it is important to introduce the concept of overdrive ratio. This is the ratio between the power supply voltage and the motor's rated voltage. An empirically derived maximum is 25:1. That is to say, the power supply voltage should never exceed 25 times the motor's rated voltage. Below is a graph of measured iron losses for a 4 Amp, 3 Volt motor. Notice how the iron losses range from insignificant to being the major cause of heating in the motor compared to a constant 12 Watt copper loss (4 Amps times 3 Volts).