

APPLICATION GUIDELINE #44

(AG#44 Energy Savings Issues with Solid State Starters)

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The following discusses the significance of the energy saving circuit feature available on some solid state starters.

Saving Energy During Starting

There are no appreciable energy savings while accelerating a load using a solid state soft start versus an electromechanical starter (i.e. full voltage starter). It takes approximately the same amount of energy to accelerate a mass (load) from zero to operating speed. The type of starter used determines the acceleration time. If the motor starting voltage is reduced, the accelerating torque (difference between the motor torque and load torque requirement) is lower and the acceleration time is longer. The starting time is usually not a substantial percentage of total running time and is therefore not considered when looking at saving operational cost.

Saving Energy During Running

The energy saving function operates during running condition by reducing the motor voltage under lightly loaded conditions. When the motor voltage is decreased, the core loss is also decreased, but the load (stator and rotor) losses increase. Between these items (voltage, core and load losses), there is an optimum point where lowering the voltage will increase the motor efficiency (where the decreased core loss offsets the increased copper losses). For typical induction motors, the load losses dominate such that motor efficiency decreases at reduced voltages.

For a three phase induction motor, approximately 20% of the total losses are core losses, while 35% are copper (stator) losses. These are typical values and will vary with motor size. If a motor has an efficiency of 90.6, only 1.88% of the 9.4% total loss is core losses. Core losses cannot be eliminated. A reduction in core loss will not exceed 40%. If a 25% reduction in core loss were obtained, this would amount to only a (.25 times 1.88%) 0.47% reduction in total motor loss.

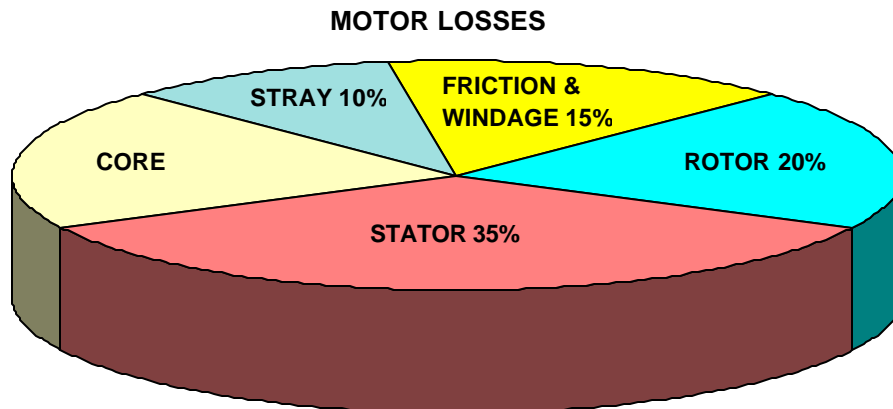


FIG.1 - TYPICAL MOTOR LOSSES (VARIES WITH MOTOR SIZE)

One article published on energy savings, using a solid state starter, only addressed motor losses. It states that a solid state starter with energy saving circuit, on a 20 hp, 480Vac, 4 pole motor, running at 40% load will save approximately 5% of full load motor power. On a particular TEFC motor, the full load efficiency is 89.5% (10.5% losses). If we assume that 20% of this is core losses, then this accounts for only 2.1% of full load power. The claim of a 5% energy savings is therefore not possible.

The article also showed an example of a 150 hp, 460V motor. The calculations show a best case scenario (24 hours/day, 365 days/year operation and 75% of the time running at 20% load). The table showed that for motors rated 100 hp and above, the load needs to be less than 30% before there is any more than 0.5% savings.

Another starter manufacturer stated they conducted tests on 10, 50 and 125 hp motors and determined that there is little savings above 50% load. In the article, a 125 hp motor showed no savings above 30% load.

System Efficiency

The information published by these manufacturers base the findings on motor efficiency only. There are several variables and other factors to be considered when determining energy savings. To determine actual (utility) cost savings, the total system (transformer, starter and motor) must be considered. The efficiency of the motor will be the same when either running through a contactor (as with a full voltage starter) or through a solid state starter (SSS) at full voltage. To provide other than a line voltage to the motor, the SSS must switch the SCRs on and off continuously. Switching the SCRs will produce less efficiency in the motor due to harmonics and increase motor heating (increased losses). The harmonics produced will also lower the efficiency of the transformer feeding the starter.

The solid state starter has its own losses. The SCRs produce heat when operating, which is watt loss. The amount of loss will vary based on the amount of current flowing and design of the starter. The SCR losses will increase due to the constant switching. Toshiba solid state starters are 98.5 to 99.5% efficient (at full load). Tests conducted on a Toshiba and other manufacturer's starters showed that there can be a great deal of difference in the temperature rise of the SCRs (losses). If a savings of 0.5-3% is believed possible (at the motor terminals) by having the starter provide a lower voltage, the 0.5-1.5% loss (higher with continuous SCR switching) in the starter will reduce and may eliminate the energy savings in the motor.

One method to achieve true energy savings, when using a solid state starter, is to use a bypass contactor. The bypass contactor closes when the solid state starter output voltage reaches full voltage, and the SCRs are then turned off which eliminates their losses. The SCRs are turned on after a stop signal is provided, and then the contactor is opened. Using this method, the efficiency of the motor is not affected during constant speed running operation. There is no switching performed on the line voltage, and the motor will see a true sinewave.

With some starters, the SCRs are left on during bypass operation. The load current flows through the bypass contactor due to the contacts having a lower path of resistance. This method of bypass also eliminates the SCR losses.

Conclusion

The “energy savings feature”, used by some solid state starters, is not a very effective method to save energy and therefore save money. The amount of savings will vary by motor rating and application. Savings are only possible on lightly loaded applications. On an application where the motor will run at less than 40% load for a substantial period of time, the amount of savings is questionable. The following items should be considered:

1. Use a premium efficiency motor (i.e. Toshiba EQP III) instead of a standard efficiency motor. For example, the difference between a standard and premium efficiency, 20 hp, 460V, 4 pole, TEFC motor can be from 2.8 to 3.5%.
2. The losses of the SCRs (0.5-1.5%) in a solid state starter can be eliminated by using a bypass contactor.
3. Applications where the “energy savings” feature on a solid state starter is useful are limited. The amount of system energy savings itself is disputable and difficult to determine. On applications where the load varies, especially on variable torque applications, and energy savings is desired, an adjustable speed drive should be considered.

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