

Background

Losses within a motor are divided into a number of different components. There are friction and windage losses, I²R losses, core losses, and magnetic losses. The friction and windage losses remain constant at full load and no load. However, at no load, I²R losses, core losses, and magnetic losses can be reduced by decreasing the applied voltage.

For example, a 30kW (40 HP) motor draws 30kW from the line to produce work. An additional amount of energy is drawn from the line due to the internal losses to the motor. If the motor is 90% efficient, an additional 3kW or a total of approximately 33kW is drawn from the power line when the motor is operating at full load.

If an energy saver could be designed to eliminate all losses in the motor, the maximum amount of energy this theoretical device could save would be the 3kW in losses. The motor would still draw the 30kW from the line, which it would convert to power from its output shaft.

The motor industry indicates that one-half of the losses could theoretically be saved. The other one-half could not be saved because of such variables as friction, windage, etc. Using this approximation with the 30kW (40 HP) motor, one-half of the 3kW losses could be saved. The maximum theoretical savings would be equal to 1.5kW. Actual applications would probably have less than the theoretical 1.5kW.

Application Requirements

Savings in energy costs are possible in certain applications. Figure 1 shows test results of actual motors. The Figure 1 graph was developed on 10, 50, and 125 HP motors.

Based on these test results and other data, there is very little savings possible above 50% load. A curve of maximum theoretical savings can be drawn using the theoretical savings of 50% of the losses and the data that indicates little or no savings above 50% load. This is illustrated by the upper curve in Figure 2.

In reviewing the test data for lower limits, it could be estimated that 20% losses are saved at no load and no losses saved at 20% load. This is illustrated by the lower curve in Figure 2.

Figure 1
% kW Saved vs. % Rated Load

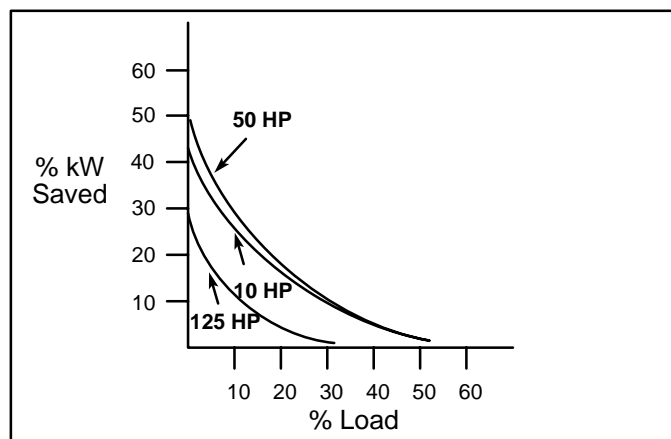
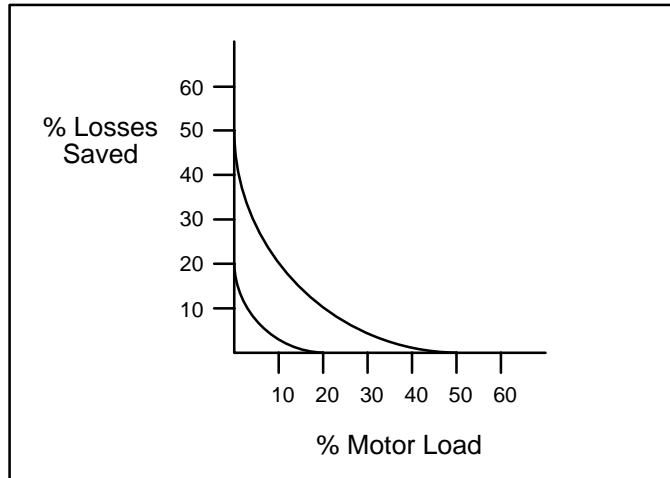


Figure 2
Estimated Energy Savings



Preliminary Estimates

A simple “full load-no load” preliminary estimate for the application of an energy saver can be made by using the following procedure:

1. Convert horsepower to kilowatts.
2. Determine the total kilowatts used by the motor by dividing the horsepower kilowatts by motor efficiency.
3. Determine the motor losses by subtracting converted horsepower kilowatts from total kilowatts.
4. Calculate the maximum theoretical savings in kilowatts by multiplying motor losses by 0.50.
5. Determine kilowatt hours saved by multiplying the maximum theoretical savings in kilowatts times the number of hours per year the motor is operated at no load.
6. Maximum theoretical savings dollars can then be determined by multiplying kilowatt hours saved times the cost of electricity per kilowatt hour.

Figure 3
Sample Calculation

Motor efficiency: 90%
Motor loading duty cycle: 50% (ON 15 min., OFF 15 min.)
Motor horsepower and run time: 50 HP, 8 hours per day, 2080 hours per year
Use the above data and the following procedure for theoretical maximum energy savings.
1. $kW = 0.746(50)$ $kW = 37.3$
2. $kW_{total} = (37.3) \div 0.90$ $kW_{total} = 41.4 \text{ kW}$
3. $Losses = 41.4 - 37.3$ $Losses = 4.1 \text{ kW}$
4. $Maximum \text{ theoretical savings} = (4.1 \text{ kW}) \times (0.50)$ $Maximum \text{ theoretical savings} = 2.05 \text{ kW}$
5. $(2.05) \times (0.5) \times (2080) = 2132 \text{ kWh per year}$
Finally, at a typical cost of \$0.08 per kWh, the estimated savings is:
6. $(0.08) \times (2132) \text{ for } \170.56 per year
NOTE: Calculations assume that the normal load is equal to the full load rating of the motor, and that the loading level is a no-load condition.

If this calculation looks favorable, then additional detailed calculations must be made to get a more exact figure on the dollars saved. Precise duty cycle and loading cycles must be more accurately estimated. Points can then be selected from the theoretical maximum savings curve. Savings for each increment of loading must then be calculated.

Note that a motor running unloaded and not connected to equipment is not the same as when the motor is connected to the equipment. Motor manufacturers should be contacted to determine the actual no-load characteristics.

These calculations have been done on the basis that a solid-state controller was required for reasons other than energy savings. If energy savings is the main reason for purchasing this type of device, the savings would be less. The reason is that there is approximately a 1 to 1-1/2 volt drop across each solid-state power pole. There are additional losses associated with solid-state devices.

For example, a solid-state controller for a three-phase motor drawing 50 amperes will have a loss ranging from 150 to 225 watts above an equivalent electromechanical device. Therefore, these losses are deducted from the total energy savings if the energy saver were replacing an electromechanical device.

