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Drive Efficiency
Eddy Current VS Variable Frequency Drives

It is common belief in the electrical equipment industry that the Eddy Current Drive is an aging technology that should be replaced by the newer variable frequency drives (VFD's).

Whether or not variable frequency drives are any more capable or reliable at performing the application does usually not enter into the discussion.

Most often the single justification for the superiority of the VFD is efficiency.
VFD drive manufacturers claim their drives are 95% efficient.
An Eddy Current Drive at ½ speed burns 50% of the input power on the clutch." This is followed by the payback charts that show a rapid investment return.
Are the above two statements true?... Yes.
Is that the whole story?... Not at all.

The untold story is about system efficiency, the difference between the power put into a process and the power that is delivered to a load.
The VFD drive manufactures neglect to mention this topic, but we, at DSI/Dynamatic, (an Eddy Current Drive manufacturer) as well as some of our customers, have done tests on this and the results are very different than stated by the VFD Companies.

Eddy Current Drives

Eddy Current Drives utilize a DC magnetic field to link two members, one on the input shaft and one on the output shaft. Increasing the DC Current to the coil increases the coupling of the two members thus delivering more torque to the load. Tachometer and or Current feedback is used to control the velocity and torque. The losses in efficiency are as follows.

1. AC Motor - Equal to nameplate rating as motor is running across the line. This is true for both power factor and efficiency.
2. DC Control Typically 2% or less.
3. Slip - Reduction in speed is dissipated in the drum and rotor (the coupled members). It reduces efficiency in proportion to reduction in speed.

The bottom line is that it is best to run an Eddy Current device at or near rated speed. Typically 82 – 100 % is recommended to optimize efficiency.

Variable Frequency Drives

From the most elementary standpoint a VFD controls motor speed by varying the effective voltage and frequency applied to the stator of a standard AC Induction motor.

The reason we use the term effective is that the applied voltage is actually a high frequency square wave, pulse width modulated (PWM) waveform that switches from bus voltage, typically 650VDC or more to 0V, thousands of times per second.

This alters the effective base speed of motor, allowing variable speed operation.
It also presents several negative effects both in harmonics and mechanically

A standard AC motor has a published efficiency and power factor. They are quite high, typically above 90%, but only for a sinusoidal excitation at rated frequency.

On a VFD the losses are higher, the power factor is lower. These values are not widely known or published. The efficiency losses in a standard AC motor are as follows.

1. IR losses – This is heating caused by resistance to Current flow in the motor winding and rotor bars. This is the largest loss. It is proportional to the square of the Current flow. There is about 5% additional caused by PWM excitation. Motor Current has two components, excitation, an inductive component, and real Current (torque producing) that delivers torque to the load. The excitation is more or less constant throughout the speed range, so it causes a larger I R loss relative to output as speed is reduced.
2. Eddy Current Losses – Losses caused by unintended Current flow in the rotor and the stator. These are limited by laminations in the stator and rotor. They are proportional to Current flow and increase with slip.
3. Hysteriesis losses – This is the heating created by reversing the magnetic polarity of the iron in the rotor and stator. This increases with slip
4. Windage and friction - Negligible relative to the others above

All of the losses above, with the exception of windage and friction, become a larger percentage of output horsepower as speed is reduced.

In addition there are two other issues associated with VFD's.

1. Power Factor – One of the advertising features of VFD's is that they present a power factor of near unity to the line. While true, the motor still operates with a lagging Current. This is extra power that the utility would have to generate if the motor were across the line. Hence, utilities charge a power factor penalty as they only measure watts. With the VFD generating this extra Current, the extra is retrieved from the line. Instead of a power factor penalty, you are forced to pay for the power up front.
   Also, the power factor degrades dramatically with speed reduction, approaching 75% at half speed.

2. Slip Losses – A less known fact is that an AC Induction motor is a magnetic clutch operating at a slip. (slip against a rotating field) The slip increases under increased load, considerably more at low speeds. At a PWM equivalent base speed of 100 RPM the motor would operate at 50 RPM if its rated slip were 50 RPM (a 1750 RPM motor). Thus, torque boost (Increase in voltage) is used to start under load. This slip is a loss that becomes a higher percentage of output as speed is reduced. If torque boost is used, the losses are higher still.

The bottom line is that an AC motor is quite efficient at rated speed and voltage, but the losses build as a percentage of output as speed is reduced. The power factor enters the efficiency equation and the control losses add in as well.

These dramatically lower the system efficiency.

The Eddy Current system loses efficiency proportionally to the speed reduction. Neither the Eddy Current nor the VFD can be considered efficient at ½ rated speed.

Finally above about 82% of base speed, the Eddy Current actually has better system efficiency than the VFD due to lower controller losses and sinusoidal excitation.

Below you will find typical test results for a 250HP 1775 RPM motor for comparison along with a test done by one of our customers on a 40HP 1760 RPM Unit.

You will note… The results are similar.

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