Environmental Potentials

Power Quality For The Digital Age

REDUCING SLIP LOSSES IN MOTORS

AN ENVIRONMENTAL POTENTIALS WHITE PAPER

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Introduction

Facilities use motors in nearly every step of the production process. Motors power conveyor systems, compressors and robotics. Most modern facilities rely on variable frequency drives to control the speed and output of motors. Indoor power pollution generated by non-linear loads, such as variable frequency drives, distort the electrical waveform delivered to motors and this results in slip losses. These slip losses decrease the efficiency and lifespan of motors

Motors

An AC motor has two basic electrical parts, stator and rotor. The stator is a stationary electrical component also known as armature winding. The rotor is the rotating electrical component generally mounted on the shaft of the motor. The rotor is inside the stator and is mounted on the motor's shaft. The motor shaft is connected to the load and thus rotating the shaft produces mechanical energy to the load.

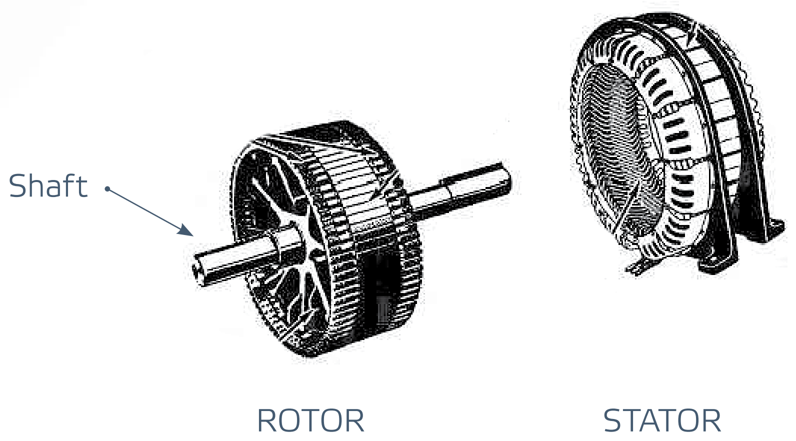

Fig.1 Side cross sectional view of stator and rotor of the motor.

Both stator and rotor consist of electro magnets mounted on their surface in such a way that the rotor poles are faced towards stator poles. Opposite poles of magnets attract, while like poles of magnets repel. Polarity of the stator poles are changed alternatively in such a way that their combined magnetic field rotates within the core. Since the unlike poles attract, stator's moving magnetic field is associated with the opposite polarity of the stator pole and thus the torque is generated on the rotor. Generated torque moves the rotor on its shaft. This association of stator moving magnetic field with the rotor is also called "synchronization." Pictorial representation of this principle is depicted in figure 2.

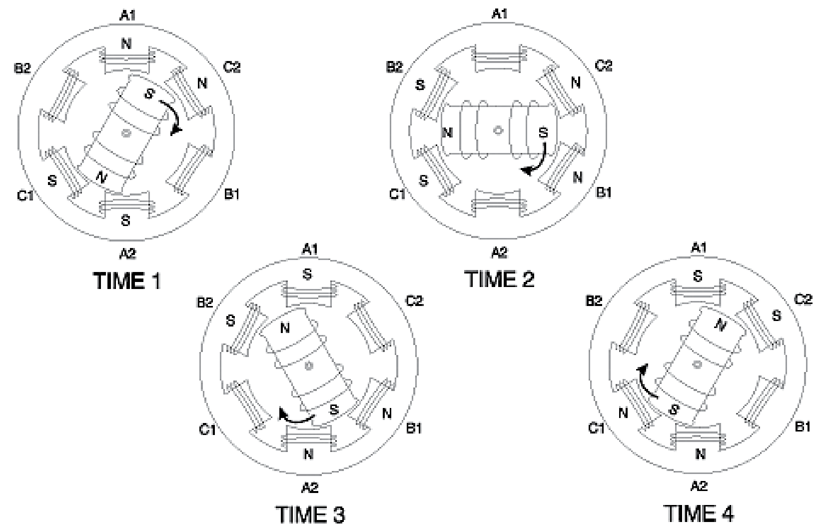

Figure 2: Motor principle: it shows how rotor is moving with respect to poles on the stator

Motor Speed and Losses

The speed at which the rotor and stator synchronizes is called synchronous speed. Motors are designed to run at specific speeds, however due to indoor power pollution, the motor typically operates a slightly different speed. For example, a motor designed for 1800 rpm might run at 1750 rpm. In this example 1800 rpm is the actual speed where as 1750 rpm is the synchronous speed. This difference in speed is called "slip speed."

The motor is performing at its maximum capability when the moving magnetic field generated by the stator is used solely to rotate the shaft of the rotor. This means that the synchronous speed of the stator and rotor, is equal to the actual speed of the shaft of the motor. In this scenario, the slip of the motor is zero and slippage between rotor and stator is zero. In reality, the rotor speed always lags the magnetic field's speed. This leads to the generation of slip between the rotor and magnetic field.

As the slippage increases, it creates electrical losses called "slip losses." When slip losses are present, the current feeding the motor must increase in order for the motor to achieve its expected output. This increase in the current magnitudes has two major consequences. First, it increases the facility's energy consumption. Second, it increases the physical burden on stator coils resulting in overheating of the stator. This generates more losses and causes premature failure of the electrical motor.

High Frequency Noise

High frequency noise is one of the major contributors to slip losses. One measure of the waveform is crest factor. A perfect waveform has a crest factor of 1.4. However, high frequency noise creates distortions on the entire length of the waveform. These distortions increase the crest factor and can create imbalance in current and voltage. This leads to improper distribution of the magnetic field.

Motors depend on a proper magnetic field to operate at maximum levels. Improper distribution in the magnetic field creates unequal speeds for the rotor and stator. This unequal speed is slip losses. Eliminating harmful high frequency noise significantly reduces slip losses.

Star of the West

Examine this real life example of slip losses at the Star of the West Mill in Michigan. The motors in this facility were experiencing high levels of slip losses and distorted current and voltage waveforms.

Figure 3: Motor performance comparison after installing EP

Star of the West Flour Mill Motor Report

Motor #	Description	HP	Load HP	Current CF	Voltage CF	Power factor	Slip	Energy Saved
655	Airlock	1	0.28	50%	50%	0	0	0
649	Tempe bin auger	2	0.39	0	60%	0	82%	3 watts/hp
702	Blower	20	10.73	0	13%	0	45%	1watt/lb-in
1006	BLower	40	28.5	0	33%	18%	0	0
10007	1st br. Mill	40	19	1%	85%	10%	75%	1 watt/hp
632	Carter Disc	3	1.94	50%	9%	2%	0	1 watt/hp
706	Tumbler	25	6.07	15%	9%	0	33%	1 watt/hp
709	Intensive Damp	15	12	93%	86%	0	23%	1 watt/hp
616	Fan	30	24	0	25%	0	0	1 watt/hp
712	Hammermill	30	15	0%	81%	33%	86%	1 watt/hp
507	Fan	60	49	5%	25%	2%	0	1 watt/hp
209	Viberator Duster	7.5	4.9	0	11%	0	41%	0
711	Scourer	25	9	0	0	5%	0	1 watt/hp
636	Heids	5	2.5	0	0	0	0	
232	Sweeper	25	20	16%	30%	0	0	0
	S. Line Shaft	75	72.56	10%	5%	0	0	0

Percent Values are the Percent improvements in motor efficiency after filtering

The percentages represent improvement. Column eight represents the percentage of improvement of slip efficiency of the motors; motor number 649 improved by 82 percent. That translates into a 3 watt per horse power of energy loss reduction per hour.

Column five represents improvement in current crest factor while column six represents improvement in voltage crest factor. Improving crest factor means that the waveform is improving thus reducing electrical losses.

The EP Solution

Slip losses in a motor are due to the nonsinusoidal nature of the electrical signal and high frequency noise generated on the electrical signal. Improving the sinusoidal nature of the waveform and removing the high frequency noise will significantly decrease slip losses.

Environmental Potentials' patented waveform correction technology corrects the waveform while eliminating high frequency noise. Installing this waveform correction technology throughout the facility at main panels, load centers and point of equipment will minimize slip losses ensuring your facility's electrical distribution system is operating as efficiently as possible.

Successful installation of the EP system can reduce energy losses by as much as 3 watts per one horsepower. Star of the West Flour Mill saved more than $42,000.00 per year by reducing electrical losses.

Conclusion

The modern facility uses motors and variable frequency drives throughout the production process. Motors have two basic electrical components, a stator and rotor. The stator and rotor rely on magnetic fields to power the motor.

Non-linear loads such as variable frequency drives generate high frequency noise and distort the waveform. This noise and distortions creates a difference between the motors synchronous speed and actual speed. This difference between synchronous speed and actual speed are slip losses. These losses can be reduced by correcting the electrical waveform and reducing high frequency noise.

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