ARMSTRONG

White paper

Design Envelope Pumps Mitigate Motor Bearing Damage

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1.0 Abstract

While the incidences of PWM adjustable frequency drives causing damage to the bearings of AC induction motors are quite rare, there is an increasing concern in the marketplace regarding such damage. Armstrong Design Envelope Pumps include a number of unique design features to reduce the likelihood that damage to motor bearing will occur. Armstrong Design Envelope pumps are complete pumping units including controls and certification to ULSTD 778 & CSA STD C22.2 No 108, TO cover NA needs. In the unlikely events of any problems the complete pumping unit has been manufactured and 3 year warranted by one manufacturer, Armstrong, who carries the responsibility for the complete pumping unit. No need to coordinate a drive, motor and pump manufacturer along with an electrician to trouble shoot problems.

2.0 Unique control features to minimize the chance of Motor Bearing Damage

2.1 Low peak voltage transitions at the stator

In many bearing failure scenarios the damage is a direct result of a large peak voltage being impressed on the motor stator windings. The Armstrong Design Envelope Pump has a number of features that limit the peak voltage applied to the motor. These include:

- Soft switching IGBTS

The rise time of the voltage pulses that the Design Envelope Pump control produces, are significantly longer than they are for most other PWM drives, particularly in the 1 to 10 HP range. As a result, the peak voltage that is generated at the motor is reduced.

- Elimination of output reactors on most drive sizes

Advances in drive current detection and shorter fault reaction times have eliminated the need for output reactors in Design Envelope Pump control. As a result, the snubber-diodes in the control's output inverter section have very little impedance separating them from the motor. Therefore, these diodes can more effectively clip voltage spikes throughout the output wiring.

- 60 Degree Asynchronous Vector Modulation (60°AVM)

The greater the stator voltage change during a PWM switching operation, the greater the voltage change imposed on the motor. It is these fast, high amplitude voltage fluctuations that are instrumental in many of the motor bearing damage mechanisms. Once the Design Envelope Pump control reaches a normal operating speed, it automatically switches to a mode where each output IBGT is locked on for 60 degrees of each output cycle and is locked off for the opposite 60 degree segment. As a result, only two pairs of transistors are actively switching most of the time. This limits the amplitude changes in the voltage that is impressed on the motor's stator. Instead of alltransistor pairs switching continuously at the drive's carrier frequency, which may be at a rate of thousands of state transitions per second, 60°AVM limits such transitions to 6 times per output cycle. At an output frequency of 60 Hz, this corresponds to only 360 of such transitions per second. At reduced output frequencies, this number is even lower.

2.2 Reduced Frequency Spectrum in the PWM Pulses

A standard PWM waveform is rich in high frequency components. The faster the rise time of the PWM pulses, the greater the high frequency components of the pulses. The longer rise time of the Design Envelope Pump control's PWM pulses reduces the high frequency component of these pulses and so increases the impedance of the capacitive paths through the motor, restricting current flow through these paths.

2.3 Automatically Controlled Carrier Frequency

Damage to motor bearings does not occur immediately. Small imperfections in the bearings build over time until the bearing's races and rolling elements cause objectionable audible noise and related problems. By reducing the carrier frequency of the pulses supplied to the motor, the service life of the bearing can be extended. The problem with this is that the carrier frequency of most PWM drives is fixed. It is often set to a high frequency in order to avoid objectionable audible motor noise when the pump is being driven at a low speed. The Automatic Switching Frequency Modulation (ASFM) feature of the Design Envelope Pump controle provides a reasonable solution. For Design Envelope Pumping units up to 60 HP (at 460V AC), when the motor is lightly loaded, ASFM will increase the carrier frequency of the drive's output to reduce objectionable audible motor noise. However, when the load on the motor increases, ASFM will automatically adjust the inverter section's carrier frequency. While this provides many operational advantages for the control, the automatic reduction in the control's carrier frequency during periods of heavy output load is the significant factor in extending motor bearing life.

Of course, the 60°AVM feature, mentioned above, has the effect of making an extreme reduction in the frequency at which the motor receives high amplitude voltage pulses.

2.4 EMI / RFI filters

Built in EMI / RFI filters help to ensure peak voltage are contained within the controls and do not travel to the motor. Armstrong Design Envelope pumps include filters as necessary toensure compliance to low emission and immunity requirements EN61800-3 to the 1st environment class CI (EN55011 unrestricted sales class B).

3.0 Other ways Design Envelope Pump Design Minimize the risks of Motor Bearing Damage

Equipment Location

It is generally best to keep the drive and the driven motor as close to each other as possible. This helps to reduce both the peak voltage that is impressed on the motor's stator windings and the impedance of the ground path between the drive and the motor. As a result, it generally makes sense to avoid mounting drives in motor control centers, where the lead length between the motor and the will most often be significantly long.

Design Envelope Pumps ensure the minimum distance possible between the control and motor as the control is integrated into the unit up to 450 hp / 350 kW and the leads are under 1 meter on small units and proportionally small up to the largest 1250 hp / 950 kW available units.

Control Enclosure

When one attempts to mount a drive near the driven motor it is also important to consider the environmental requirements of the drive. Placing the drive in a significantly wet, dirty, or hot location is never a good idea unless the environment is considered when selecting the drive's enclosure. Many drives are simply Nema 1 / IP 20 rated enclosures.

Design Envelope Pump Controls have a minimum enclosure rating of Nema 12 / IP 55.

Grounding

Proper grounding is essential when designing a system that includes PWM adjustable frequency drives. Items to consider include:

- Do not rely on conduits to provide the ground. These do not provide a reliable, low impedance ground for the high frequency components that are associated with PWM drive operation.
- Size ground wires appropriately. The size of the ground wire will generally be larger than would be used if a plain constant speed motor starter was used. This large wire size helps provide a low impedance path for the high frequency components that are associated with PWM drives.
- Wire the ground to the drives properly. Each drive should be supplied with its own ground wire that returns to a reliable electrical ground. Do not "daisy chain" a ground wire from one drive to another.
- Run an individual ground wire in the conduit between each drive and its motor. As with the drive ground wire, this will likely be a larger wire that you would generally use. This again is to ensure that the high frequency ground currents that this wire carries don't experience too much impedance.
- Do not run the motor wiring for more than one drive in a single conduit. While there are a number of reasons for this, the concern here is the ability to minimize the impedance of the ground lead. This is helped by keeping the ground wire for a motor as close as possible to its motor leads since the resulting magnetic fields can then more easily cancel.
- Ground the driven equipment to the motor. Use a ground strap to ground the motor to the equipment that it is driving. The idea here is to help ensure that there is no voltage difference between the voltage of the driven equipment and the voltage of the motor's shaft. If there is no voltage difference, grounding currents won't flow through the motor's drive end bearing, through the motor shaft, and into the driven equipment.

Design Envelope Pumping unitsare constructed and assembled in a clean factory environment to exactly standards and the complete pumping unit is certified to UL778 requirements. The pump end and motor units are bolted together in a metal to metal fit assuring grounding. Every unit utilizes the best practices in wiring and grounding.

Design Envelope Pump speed change

There is incidental evidence that running a motor at a constant speed can contribute to bearing damage. It is theorized that a vibration can be established in the rolling elements of the bearings that tends to make all discharge currents occur at the same location on the bearing. Changing the speed of the motor occasionally breaks up this vibration pattern.

Design Envelope Pumps incorporate sensorless speed control and when used in an installation ensures the pumping unit continuously reacts to the changing demand of the system and therefore continuously varies speed.

4.0 Summary:

Armstrong Design Envelope Pumps include control features, electrical and mechanical standards assured by factory environment assembly and complete unit certification to UL 778 which all minimize the risk of motor bearing damage. In the event of any problems the complete unit supply by Armstrong means one source responsibility under a 3 year warranty. No need for customer coordination of electrical and mechanical contractors and pump, motor and drive manufacturers. Armstrong does not recommend the use of insulated bearings or shaft grounding on Design Envelope Pumps.

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