OPTIMIZE THE LIFE AND PERFORMANCE OF ROTARY ENCODERS THROUGH CORRECT MOUNTING

Cory Mahn
Senior Product Engineer
Dynapar Corporation
1675 Delany Rd.
Gurnee, IL 60031
USA
Cory.Mahn@Dynapar.com

Abstract - Encoders are a physically small component of a complex system that allow manufacturers to make quality parts or move objects from point A to point B in a swift smooth motion. If you break down this system into its major physical components, it includes a motor, a drive or amplifier, possibly a brake, and an encoder. When it comes to mounting, the encoder requires the most thought. This paper explains the spatial, environmental, and mechanical reasons why different mounting methods exist, and how they can benefit the application. We'll also explore what happens when installations are done incorrectly.

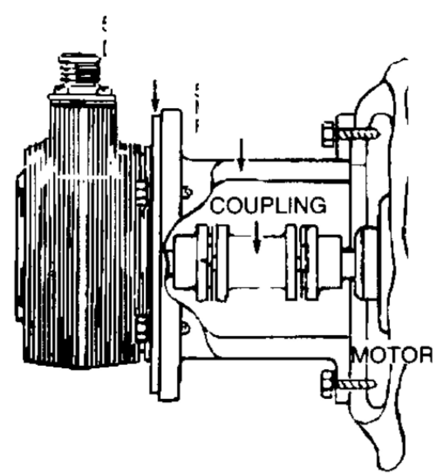
1. INTRODUCTION

Encoders are a component in motion control systems that provide feedback to drives for accurate speed and position control, and specifying an encoder is a task that can appear to be a difficult endeavor. Major encoder manufacturers continue to release new series of encoders and maintain a large fraction of their legacy lines for customers who want to enjoy the freedom of worry about their encoder availability. Options within each encoder series also seem to be growing.

Although, the interface and electrical options within each encoder series seems lengthy, this decision is made for you. When you select a drive, the drive specifications will contain the appropriate input options that must be chosen.

Encoder mounting is the most significant aspect that divides their identity, and appropriate selection can optimize both the life and performance of the encoder. Having the right mounting option is like having "the right tool for the job."

2. COUPLING



2.1 COUPLING DEFINITION

When a flange or foot mount encoder is chosen, it can be mounted to a motor with the use of a coupling and an adapter. A coupling fastens to each shaft through the use of set screws, and has spring or mechanical isolation from shock, vibration, or movement in the motor shaft. This is also typically done when an encoder is matched to an older non-standard motor, when a specification of the particular encoder does not exist in ring or hollow shaft encoder, or the shaft movement is too strenuous for a standard encoder to handle.

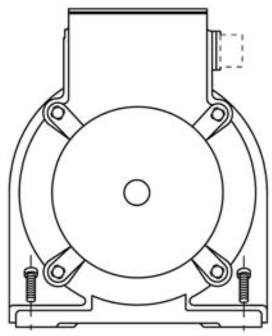


Figure 2: Foot Mount Encoder

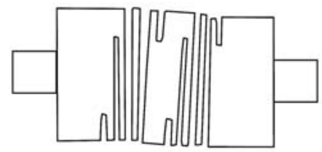
Foot mount encoders are also coupled to motor shafts directly or they are belt driven. It's also done for same reasons as flange encoders. However, the body is no longer mounted directly or indirectly to the motor face. It is mounted to the same horizontal surface as the motor. Foot mount encoders also typically have a Nema 56C face on them to mount gear trains or possibly another ring encoder (*Section 4*) to them.

2.2 Benefits of Coupling

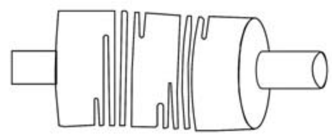
Isolating the encoder through coupling has several advantages. Using this method of mounting typically provides electrical isolation from the motor. When electrical isolation does not exist, the encoder is susceptible to noise induced by the high currents supplied to and generated by the motor. If there is electrical noise, then the encoder output may have missing pulses, added pulses, or the encoder could get damaged.

Mechanical isolation is also a benefit. Flexible couplings can absorb shaft movement which can allow for installations on older motors or motors that are used in high shock and vibration applications.

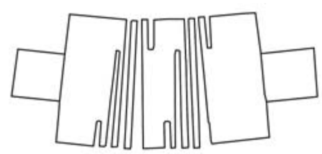
2.3 Coupling Considerations.



a. Parallel



b. Skewed



c. angled

Figure 3: Coupling Misalignment

The disadvantages of using couplings are mostly mechanically related. The primary disadvantage of using couplings is the added length required in line with the shaft. Coupling an encoder can add up to seven inches in line with the motor shaft when you consider the bracket, the shaft gap within the coupling, and the encoder housing. Coupling an encoder also adds multiple steps of installation.(i.e. shaft alignment and hardware tightening)

When installing a coupling, misalignment in any of the forms shown in Figure 3 can have undesirable side effects. Most importantly, the coupling undergoes avoidable stresses. These stresses can eventually cause the coupling material to tear or break.

Lastly, misalignment can have an effect on speed feedback. This effect is similar to that illustrated by the output velocity of a driven shaft in a universal or Cardan joint as shown in Figure 4. (Unknown, 2002). The ripple in velocity can cause drives to fault or goods to be damaged due to excessive vibration.

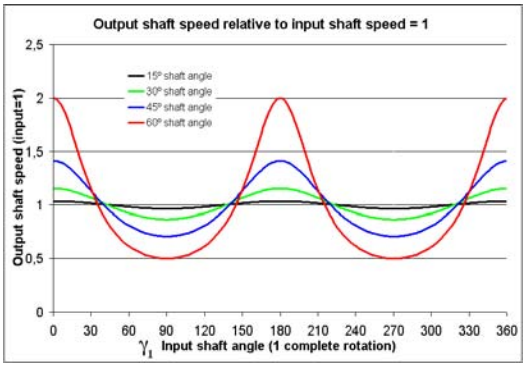


Figure 4

3. Direct Mount with Tether

3.1 Definition

Direct mounting with a tether places the encoder directly on the shaft of the motor. The encoder does have bearings, so there is no mechanical alignment that is required. It also has a rod or sheet steel tether that bolts to the motor face or any fixed object to keep the body of the encoder from rotating.

Motors are driven by different types of voltage sources, and each voltage source induces different types of shaft and bearing currents. (Baldor-Reliance, 2002) To protect the encoder and motor bearings, the shaft of a direct mount encoder is typically isolated by the use of a plastic sleeve between the motor and encoder shaft. Encoders that do not have the plastic sleeve or insert rely on the motor for a shaft current solution or another shaft grounding kit accessory.

3.2 Benefits of Direct Mount Encoders

Matching the appropriate encoder with the motor may be easier with direct mount encoders. With ring kit encoders (*See Section 4*), the exact details of the motor face are required. Slotted tethers allow for mounting at various radii from the center of the shaft.

Shaft installation requires no alignment with respect to a sensor. This means that once the collar is tightened, the shaft portion of the installation is complete.

Encoders that have a plastic shaft insert or plastic fastening components can save the life of the bearings, and the two high economic impact areas of the system: the motor and encoders.

With the use of spring tethers, the impact of sudden shaft movement is absorbed. This is another element of design that saves bearing life in the encoders.

3.2 Direct Mounting Considerations

Direct mount encoders typically have a larger moving shaft against the encoder housing. This means that there is a larger area in the point of entry to the electronics than you would see in a coupled encoder. Ring encoders (*Section 4)* have no entry at all through the shaft. Encoder manufactures are constantly developing new ways to improve this situation. One of which is the use of labyrinth seals.

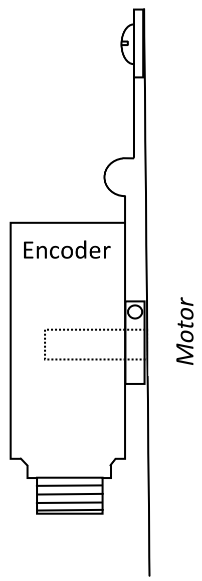


Figure 5

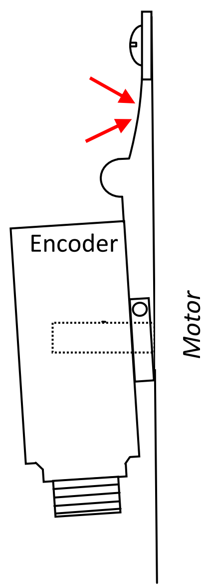
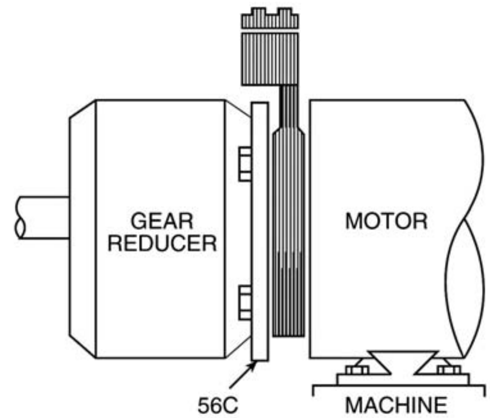


Figure 6

The encoders should be slid on the shaft with two hands or a balanced fixture. To increase the life of the spring tether, the encoder should also be placed at an optimal position. Figure 5 illustrates a balanced illustration. Since the bores are intentionally over sized, installing an encoder by placing force at one point of the encoder housing will cause it to settle in an angled position. This puts stress on the tether as shown in Figure 6. Also, when the motor is running, cycling at this stress point causes fatigue in the metal, and both stress and fatigue will eventually cause a break or tear at that point.

4. Ring Mount Encoders



4.1 Ring Mount Definition

Ring mount encoders come in a minimum of two main pieces: the sensor ring and a magnetic wheel. The ring mounts to the drive or accessory end of the motor, and uses pilot dimensions that comply to a NEMA or IEC standard. The wheel is then inserted onto the shaft, and aligned to the sensor embedded within the ring, and fastened into place.

4.2 Benefits of Ring Mount Encoders

Since the wheel moving inside the ring is picked up by a separately mounted part with no mechanical connection, the sensors can be potted along with the electronics. This is an improvement over direct mount encoders that rely on the integrity of a series of connector and shaft gaskets. Encoders, like these, are seen most often in the paper industry where air born paper fiber or dust can built up, or in areas in which machine wash down is required.

Liquids also have little effect on the magnetic technology that is typically used in ring encoders. This means that the encoder's moving parts can be partially or entirely submerged.

Ring encoders do not contain bearings. There is an air gap that surrounds the wheel within the ring housing. Momentary shock is much less likely to cause catastrophic damage since shape and pre-load of bearings are essential to providing good quality signals from a coupled or direct mounted encoder. Slight movement in the shaft as it rotates does not cause spring force on the bearings and fatigue in tethers or couplings.

Ring encoders also take up less space along the shaft the motor. They mount directly to the face of the motor, and the encoder can also have a mounting surface on the opposite side for brakes or gear boxes.

4.3 Ring Mounting Considerations

The primary concern in mounting these types of encoders is the alignment of the wheel with respect to the sensor. This is not a factor in coupled or direct mounted encoders since the sensor is aligned by the factory. The quality of the signal is entirely dependent on the installer's ability to properly align the wheel of the encoder. Wheels can also appear to be aligned, but once the shaft moves may go out of alignment. It is essential to make sure that the encoder wheel lies in the center of its radial and axial movement. Different manufacturers provide different instructions for accomplishing this. If this is all done properly, and the application environment matches its ratings, then it will likely operate for many years.

5. Conclusion

Coupled, Direct Mounted, and Ring encoders are the primary mounting options that will be used in motor feedback applications. They will all have their place according to the environment they are installed in, the age of the motor it will be installed on, and the mounting provisions that exist in the application.

Bibliography

Baldor-Reliance. (2002). *Inverter Driven Induction Motors Shaft and Bearing Current Solutions.* Fort Smith: Baldor Electric Company.

Unknown. (2002, November 7). *Universal joint*. Retrieved November 17, 2009, from Wikipedia: http://en.wikipedia.org/wiki/Universal_joint

Author Bio

Cory Mahn graduated from Milwaukee School of Engineering with a Bachelor of Science degree in Electrical Engineering Technology. He has been working primarily with speed and position feedback sensors for ten years. He has also worked with drive and motion controller manufacturers worldwide to help improve their technology.