Eddy-Current Drives

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Introduction

Most electrical adjustable-speed drives fall into five general categories: adjustable voltage dc, adjustable frequency ac, adjustable voltage ac, wound-rotor motor, and eddy-current coupling drives. This article describes the basic eddy-current drive.

Eddy-Current Principles

Electromagnetic drives, or eddy-current couplings, have more in common with mechanical adjustable speed drives than they do with other electrical drives. These drives use a speed adjustment mechanism located between a constant-speed motor and the load rather than an adjustable voltage or frequency power supply controlling the speed of dc or ac motors. Another aspect in common with mechanical drives is that they are inherently single-motor units. The drive unit consists of a constant-speed ac induction motor and a magnetic clutch or eddy-current coupling. The variable-speed output shaft is rotated for the constant-speed ac motor through the action of the eddy-current coupling.

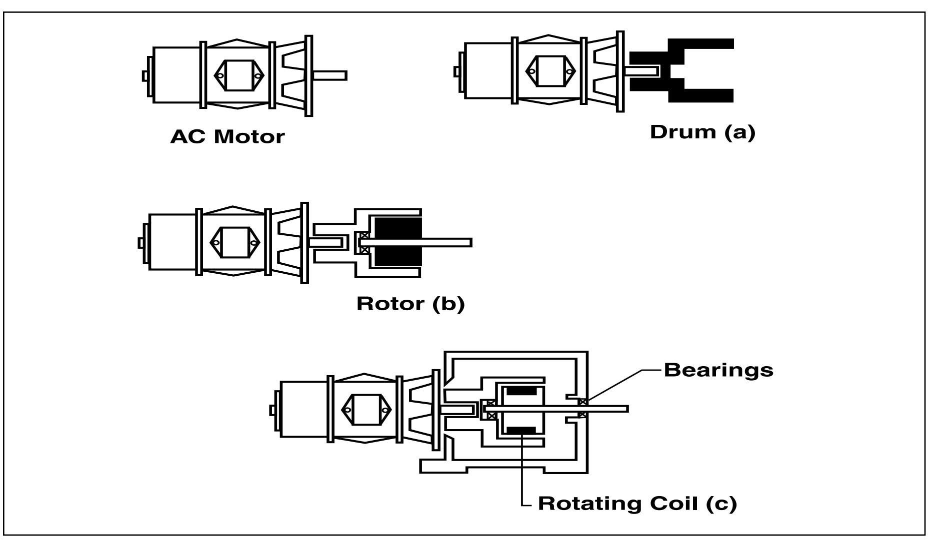

Figure 1

To better understand this concept, refer to Figure 1. As illustrated, the eddy-current coupling consists of three basic members: (a) the driving member or drum assembly, (b) the driven member or rotor assembly, and (c) a magnetic member, which is the field coil assembly. Designs with either a stationary field coil (without slip rings) or a rotating field coil (with slip rings) are available.

DC voltage applied to the field coil produces the primary magnetic field. The output member generally is a hollow iron cylinder or drum which surrounds the rotor. The drum is connected to the drive shaft of the constant-speed ac motor and rotates at the same speed as the motor. Although some couplings reverse the input and output roles of the drum and rotor, they all operate on the same principles. When the field coil is energized, magnetic lines of force emanate from it, flowing through the north poles of the rotor into the drum, through the south poles of the rotor, and back to the field assembly, producing the primary magnetic field. As the drum rotates, the lines of magnetic force are cut by the drum and causes eddy-currents to be generated on the drum, which, in turn, set up secondary magnetic fields. Interaction between the primary and secondary fields transmits the torque between the drum and rotor, inducing the rotor to rotate in the same direction as the drum. (In eddy-current drives, reverse rotation is not possible.)

With no current flowing through the coupling coil, the rotor and drum assemblies are free to rotate independently of each other. Under this no-current condition, the drum assembly rotates at full motor speed with no rotation of the output shaft. As current is applied to the coil, the output shaft picks up speed and continues to increase as long as the coil remains energized, until it is rotating at a speed slightly less than the speed of the input member, i.e., the ac motor/ drum assembly.

The speed of the output shaft will never exactly match that of the motor since some slip is required to generate eddy currents and transmit torque. Slip, in this case, refers to speed difference between the drum and the rotor. With a controller that can automatically vary the amount of coupling coil excitation, the output shaft speed can be held to some preselected rate. An important aspect of eddy-current couplings is that they are neither torque nor speed increasers.

The Eddy-Current Drive Output Torque

The output torque is essentially equal to the input torque since friction, windage, and inertial torque are usually negligible.

As shown in Figure 2, with a fixed amount of excitation applied to the coil, the output speed of the clutch will vary as the load is increased or decreased (points 1 and 2 of the torque speed curve). While this feature is desirable in some applications, the critical aspect of an adjustable speed drive is its ability to maintain a set speed with a varying load.

By varying the level of excitation to the coil, the amount of linkage effect and, consequently, the amount of torque transmitted from the ac motor to the output shaft can be varied. (See points 1 and 2 of the torque-speed curve in Figure 3.) Varying the output shaft torque enables the adjustable speed drive to maintain a set speed with a varying load. Torque transmission is accomplished magnetically without physical contact of members. Consequently, there is no wear to require adjustment and replacement of parts.

Speed Control

The eddy-current driver shown in Figure 4 (the input member as previously indicated), is usually driven by an ac motor. Output speed is maintained by a tachometer generator of the permanent magnet brushless type, mounted integrally with the output shaft, which provides a signal proportional to the output speed. This output is compared with a settable speed reference voltage signal, and the difference error is fed into a regulator/controller controlling the level of excitation to the clutch coil. This level of excitation can be adjusted or corrected to realign the actual speed to the set speed when the load is varied.

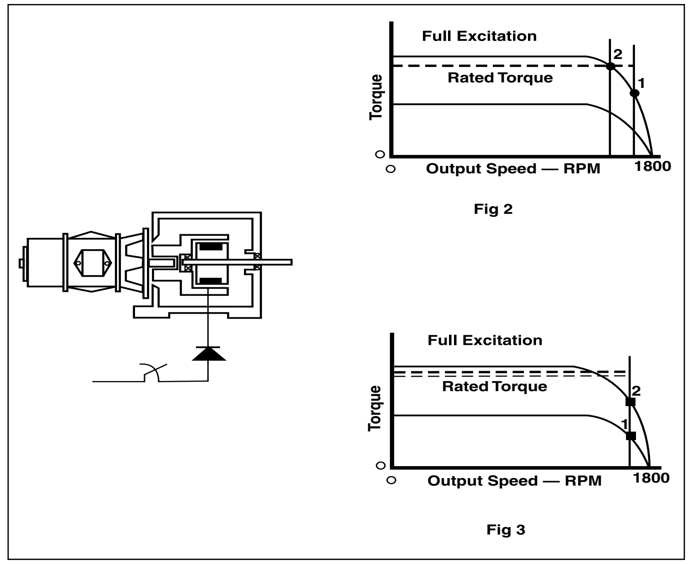

Figure 2 and Figure 3

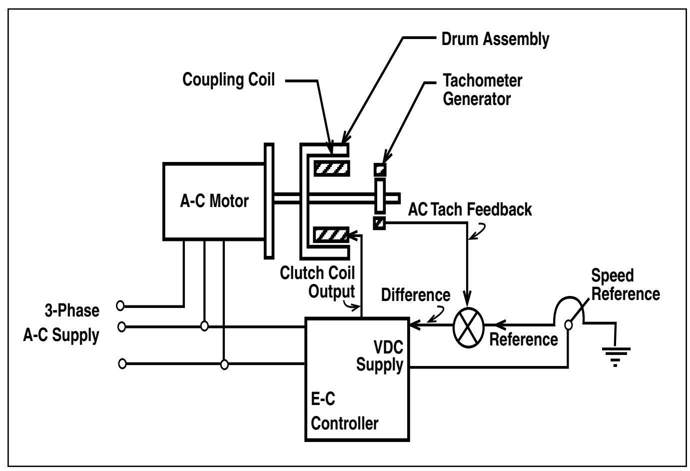

Figure 4

The degree of accuracy of realigning the output speed to the set speed is a measure of the performance of the regulator. Power to the coil is typically in the range of two percent of the total drive power requirements. The tachometer, which provides speed reference feedback, allows typical regulation of one-half to one percent. Eddy-current drives offer a 34:1 speed range and can transmit up to 250 percent of the rated torque intermittently.

Eddy-current drives have been in operation for the last 70 years and have been and still continue to be used in industrial applications where controlling the speed is the primary requirement. Their application is mostly found in the following industries:

- Metal forming/stamping process
- Asphalt/aggregation material handling
- Conveyors
- Paper
- Fans, pumps, and blowers
- Packaging
- Cement
- Winders
- Processing machines

Frank Briganti has over 30 years experience in electrical engineering and management. He has worked in the areas of antenna design and testing for the Lunar Excursion Module and the C5A Transport. He held a number of technical and managerial positions with aerospace, industrial, and construction companies. He has a BSEE in electrical engineering and an MBA in business management. Frank is currently employed as an application engineer at Electric Maintenance Service Co. in Bridgeport, CT specializing in electrical variable speed drives, controllers, VFD's, motors, and motor control products.