Comparing Differences In Wye-Delta And Part-Winding-Start Connections

By Chuck Yung
EASA Technical Support Specialist

One of the most misunderstood winding connections is the part-winding start. Many customers (and some members) tend to blur the differences between the part-winding-start (PWS) connection and Wye-start, Delta-run connections.

Let's review the Wye-Delta first before looking more closely at the part-winding-start connection. The Wye-start, Delta-run connection is designed to reduce starting current, heating of the windings and rotor, and starting torque. It does this by temporarily connecting the motor for a voltage higher than line voltage.

A motor designed for a Delta connection at 460 volts, reconnected Wye, would produce the same flux (and torque) at 796 volts:

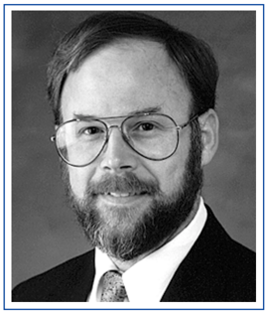
[460 x $\sqrt{3}$ = 796]

When starting in Wye and energized with line voltage — in our example, 460 volts — the motor current, torque, and I^2R losses are all reduced. Available torque is proportional to the square of the applied voltage, so when we effectively apply 58% of "rated" voltage, the motor produces one-third as much torque:

460/795 = .58; .58 squared = .33

Extended Starting Times

Because less heat is generated, the windings can handle extended starting times, and because torque is reduced there is less mechanical strain on the motor and driven load components.



This makes the Wye-start, Delta-run a natural choice for a centrifuge, fan, or similar high-inertia load. For example, a centrifuge may require an acceleration time of 10-20 minutes in the Wye configuration.

Contrast that to the PWS connection. Typically, half the winding is energized, but with ***full line voltage***. Since the winding is divided into parallel circuits, the energized portion of the winding will draw the same current as it would under across-the-line starting conditions. But since part of the winding is not energized, the line does not see as much current as it would under full-winding across-the-line conditions.

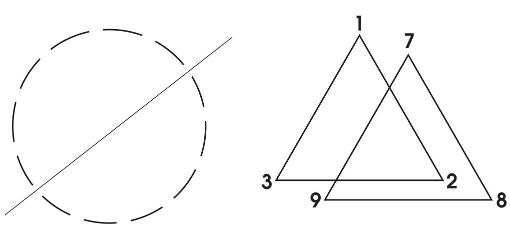
Think of this as two parallel circuits. Each carries half the total current, so when only one half is energized, the line current during starting is also half. Since torque is proportional to current, the motor only produces half the normal starting torque during this period. (This varies among PWS schemes, and is usually between half and 80% of the full-winding current.) That is the key to the PWS connection.

"Advanced Warning" For Power Supply

Used mostly in locations with a "soft" electrical system bus, like an irrigation pump or a municipal water pump station in a remote location, it's intended to give the power supply advanced warning that the motor is about to need more power.

Consider a basic system: a generator powering several motors. When a motor starts, the voltage regulator senses the increased demand and recognizes the need to produce more power. The regulator boosts the field excitation voltage, increasing generator output.

That is exactly what happens when the pump motor starts. The start sequence alerts the power company that the line needs more power. The



One common PWS connection divides the winding in half.

Comparing Connections . . . *Continued*

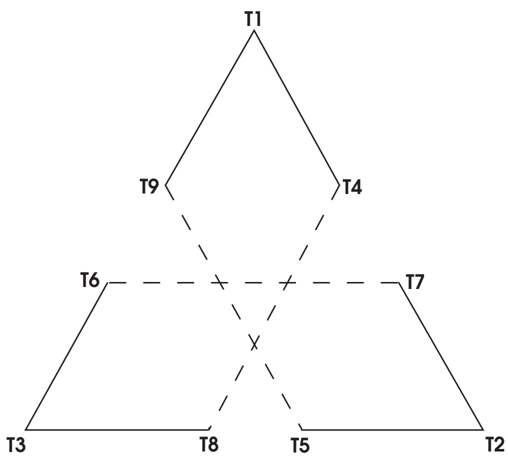
line responds fast — within several cycles — so when the remainder of the winding is energized, there is sufficient power to avoid voltage dips. We don't want the neighbor's TV to flicker, or their computer to trip off.

The part-winding start helps the power company avoid those problems. Because the generator (or power company) responds so fast, the timer for a part-winding start should be set to less than 3 seconds.

Guard Against Excessive Heating

Remember, the part of the winding being energized for the start sequence is drawing its normal share of current, so it is heating up quickly. We need to protect that portion of the winding from excessive heating. This is a critical reason for keeping the part-winding time to a minimum.

Because there are several PWS schemes in use,



Double Delta PWS

we do get calls about a PWS motor that "won't accelerate to speed." Sometimes, the motor won't even turn until the remainder of the winding is energized. That is OK. Unlike the Wye-start, Delta-run connection, the role of the PWS is not to accelerate the load, or provide reduced torque. Its main function is to minimize voltage drop. That keeps nearby lights and electrical equipment from flickering, which keeps the neighbors and power company happy.

Now, let's consider another PWS method, one that energizes the entire winding. By taking the parallel circuits and temporarily connecting them in series, the effect is similar to that of the Wye-start, Delta-run method. If the normally paralleled circuits are temporarily connected in series, the winding is connected for twice line voltage.

Half Voltage Relieves Stress

Since the winding is now starting at half voltage, less heat is generated in the windings, and that heat is distributed uniformly throughout the entire winding. At half voltage, the motor produces one-fourth of normal torque [1/2 squared = 1/4] so less mechanical stress is placed on system components.

The result tends to be better acceleration, reduced harmonics, and less heat generated in the windings and rotor. All in all, it results in a gentler start for the entire system. And as we all know, reducing strain on windings and bracing is a good thing to do.

When Westinghouse used this starting method many years ago, it was called an "extended Delta" and sometimes required a double-cage rotor. General Electric and Emerson Electric (formally U.S. Electrical Mpotors) call it a "double-Delta," and use it on many of the water pump motors they build.

Like many of today's modern manufacturers using die-cast aluminum rotors, Emerson Electric uses a double-cage bar design. That makes this starting method a viable option for the service center.

The bottom line is that this PWS connection has some unique advantages.

A potential drawback is that it produces about one-fourth the torque, while the more conventional PWS connection (where half the winding is energized) produces roughly half (1/2 to 3/4) torque during starting.

Because the PWS connection is used primarily on pumps, which are a variable-torque load, the lower torque during starting is rarely a concern.

For the EASA service center, it's valuable to be aware that there are several PWS methods in general use.

And one last comment: some PWS methods are noisier than others. While most applications are not noise-sensitive, a PWS motor in a quiet office building means that care should be taken to duplicate the original connection.