Coupling Selection with Variable Frequency Drives

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Variable frequency drives (VFD’s) and variable-speed electric motors have been a mainstay of industrial automation for decades, with ever-growing popularity. A VFD’s ability to adjust a motor’s output speed and torque can provide many customers significant improvements in productivity and efficiency over traditional systems. However, the unique properties of VFD’s can also present challenges when designing the driven equipment, especially when selecting a coupling for the driven shaft. Coupling selection typically assumes that the attached electric motor is running at 1800 rpm at the nameplate horsepower. When this assumption is no longer true, questions can arise as to how the coupling should be sized. This paper seeks to answer some of these questions by examining how VFD’s work and what that means for the coupling on the other end of the motor.

There are three load types for which VFD’s are usually applied: variable torque, constant torque, and constant power. In a variable torque application, the motor’s torque scales proportionally with speed (either linearly or quadratically) until it hits the motor’s full speed rating. In a constant torque application, the motor’s nominal torque is maintained while the speed can be varied anywhere up to the motor’s rated rpm. And, in a constant power application, the power output is held constant as the speed is driven above the motor’s synchronous speed. The torque decreases proportionately as the speed is increased. See the graph below for each of these three applications.

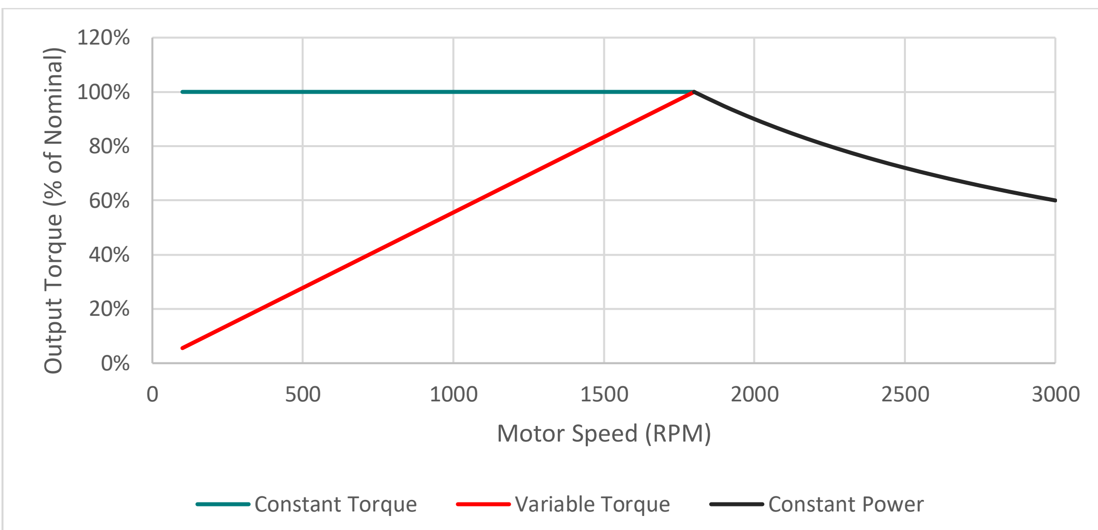

Table 1: Graph of Torque vs Speed for different VFD load types

Notice that in all three cases, the maximum torque output is 100% of the motor’s rated torque (based on nameplate hp and rpm). This means that with a VFD, most coupling applications can still be sized based on the motor’s nominal torque, multiplied by an applicable service factor and any relevant speed reductions.

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However, a variable-frequency drive does not provide a smooth, sinusoidal output like typical AC power. Instead, the VFD outputs pulses of voltage in a steady pattern that attempts to simulate a sinusoidal waveform. This causes the output torque of the motor to pulse as well. With older VFD designs, these pulsations would result in chatter with metallic or jaw-style couplings. Newer VFD technology can more closely emulate the waveform of AC power, but still generates chatter that can damage certain coupling styles.

In general, elastomeric couplings are recommended for use with VFD-driven motors due to their resilience to vibration and uneven loading. Elastomeric couplings are able to dampen vibration and absorb shocks, smoothing out the pulsating torque and protecting your driven equipment. Rubber coupling elements are particularly effective in such applications due to their lower torsional stiffness and exceptional resistance to hysteresis, the heat that builds up in a coupling due to internal friction. The effect of hysteresis can cause some elastomeric couplings to fatigue and melt prematurely when absorbing high levels of vibration. Rubber couplings have a higher heat capacity and better thermal conductivity which, combined with lower torsional stiffness, allow them to absorb much more of the kinetic energy from vibration and dissipate it as heat. See the table below for the suitability of different coupling styles for use with a VFD-driven motor.

Coupling Style	Coupling Material	Suitability for VFD Applications
Tire	Rubber	Excellent
Tire	Urethane	Fair
Sleeve	Rubber	Good
Sleeve	Hytrel	Not Recommended
Jaw	Rubber	Good
Jaw	Urethane	Fair
Jaw	Bronze	Poor
Grid	Metallic	Poor
Gear	Metallic	Poor
Rigid	Metallic	Fair

Table 2: Suitability of various couplings with VFD's

In general, coupling selection for applications that use variable-frequency drives is not much different than a typical constant-speed application. However, the unique properties of a VFD’s square voltage waveform require a coupling capable of damping and transferring a pulsating torque load. ABB’s Mechanical Power Transmission engineering recommends tire-style couplings with rubber elements as the ideal solution for these applications.

For questions regarding Dodge coupling products and selection, please visit new.abb.com/mechanical-power-transmission or contact ABB Mechanical Power Transmission engineering by phone at 864-284-5700 or by email at brgpttechsupport@us.abb.com.

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