AC Variable Frequency Drives

AC variable frequency drives
Vol. 27 #2, November 2000

The AC variable frequency drives have taken over perhaps a third of the extruder drive market and the lion’s share of downstream film, sheet, and probably winder drives. They are definitely more cost effective below 40 hp, and are reasonably cost competitive probably through 150 hp. While a decade ago they were available, the drive regulators were felt to be complex and somewhat trouble prone. Today’s drive regulating computers or chips have the capability of being programmed to accomplish a wide variety of functions, and have become quite reliable and maintenance free. AC motors have several inherent advantages over DC motors in the usual extruder market:

- They have no brushes or commutators, therefore no brush and commutator wear, and no susceptibility to failure due to the fumes inherent in many extrusion plants coating the commutators. Both of these factors contribute to low maintenance costs.

- Unlike DC drives with their power factor decreasing linearly below .85 as motor speeds decrease from base speed, AC drives rectify the full A C wave form, thus impose a power factor on the incoming AC line of close to 1.0.

- In the unusual extrusion applications involving the need for explosion proof drives, AC motors have a great cost advantage over DC because of the lack of commutator and brushes (therefore sparking), thus can easily be made explosion proof.

The motors used in AC variable frequency drives must be "inverter rated." (NEMA M G 1) for the high voltage spikes that are inherent with these drives, but this is not a major cost burden.

Description

The first functional "block" in the drive regulator is a 3 phase, AC to DC rectifier, which converts the 460 Volt, 60 Hz incoming power to DC, and puts it on the "DC buss" at approximately 625 to 650 volts, DC. The next functional "block" draws power from the DC buss, and directs or discharges it in a very large number of very short duration "bursts" or "pulses" of energy (timed so the R M S, or Root Mean Square, voltage simulates the sine curve of AC power) into the 3 phases the AC motor utilizes, obviously maintaining the 120 deg. intervals between the three phases for which the motors are designed.. The drive’s computer is timing and "picking off’ the pulses, modulating their width, and directing them to the respective phases.

Because AC motors can operate over a wide range of speeds as long as the ratio of RMS voltage to AC line frequency applied to the motor is maintained at a constant, the drive regulator can be set to deliver the AC, 3 phase power anywhere from 60 Hz (or higher in "extended range"), the common US incoming power frequency, down through 30, through 6 and even down to 6/10 (and even to zero) Hz. With the usual 4 pole motors, this results in 1800, 900, 18, or 1.8 or zero motor shaft synchronous rpm, respectively, or with the slip designed into the motor, 1750, 875, 17.5, and 1.75 motor rpm. The drive computer must "space out" the bursts of energy along the sine wave, all at full DC buss voltage, to maintain that constant RMS voltage to hertz ratio.

The several drive manufacturers have evolved several variants of this theme.

The simplest is "open loop" control, or control of motor speed with no feedback, thus no correction for sudden load changes or drift. A second is adding an encoder, which the drive computer reads to improve speed regulation and range. A third is adding dynamic braking capability to the drive just previously described, such that should the drive speed up on load shedding, energy is soaked up by dynamic braking resistors, and the drive slows down. These several features yield differences in low speed torque characteristics. speed of response, regulation, and extended range (equivalent to the DC field regulated, constant Hp range) torque capabilities.

The author is pleased to acknowledge the assistance of John Shallbetter of Rockwell Automation in preparing this description.

- Donn C. Lounsbury, D.C.L. Solutions Inc.

See also:

- AC drive update
- Extruder drives
- The extruder drive

Return to Consultants' Corner