The Extruder Drive

The extruder drive
Vol. 25 #3, December 1998

The extrusion process is one of the most demanding drive applications because of the breadth of the requirements. For example, on a 4-1/2" extruder, screw rpm's range from the 25 to 30 range for RPVC; through the 60 to 85 rpm range for Pcarb, PET's, stiff Linear PE's, and some PP's; through the 100 to 160 rpm for some L & HDPE's, some PP's, ABS, FPVC, and nylons; to 200 on HIPS. Utilized hp ranges from 80 to over 250 over those ranges. This requires the machinery manufacturer to have available a wide variety of gearcase ratio options, as well as drive options.

Most production sized extruder drives, today, are still DC, statically rectified, though the variable frequency AC vector drive is becoming price competitive up to the mid hp ranges.

The most common drive, today, is still the 1750-rpm base speed, DC static drive, so let us start our review of drives with that, using it as a springboard to extend the horizons of our understanding.

In North America, the common 1750-rpm base speed DC drive is one which operates off a 480V, 3 phase, AC power supply. It has an electronic component or regulator which utilizes that 460V AC to generate a 0 to 500V DC armature supply and a 300V DC field supply. The field supply utilizes only a few amps, but it is the wall or base against which the magnetic forces of the armature current "push off' or react. The strength of that push off or reaction is directly proportional to utilized armature current, and is called torque. Horsepower is torque times rpm (with a conversion factor).

It is a characteristic of DC motors that, as voltage is varied from nameplate down to zero, the rpm will vary also from nameplate to 0 rpm, or looked at conversely, as voltage is raised from 0 to nameplate, speed will increase linearly from 0 to nameplate. If full armature amperage is demanded by the load, the motor will deliver from 0 to nameplate hp, as it is delivering full, constant, torque. If the load to which the drive is connected is not the full nameplate torque of the motor, than armature amperage will be less than nameplate, but speed will still follow the linear 0 to 500V = 0 to nameplate rpm. The operational region thus described is called the (armature) "voltage regulated" range or "constant torque" range of the motor.

The "base speed" of a motor is that speed which the motor will turn when the full nameplate armature and field voltage is applied (usually 500V DC). DC drives can be designed such that by reducing the field voltage, they increase speed above base speed. In our example above, this might be a 1750/ 2000 rpm motor, indicating base speed is 1750 rpm, and the speed may be field regulated to 2000 rpm, a 10% speed addition. Alternately, it might be 1150/ 1700 rpm motor (a 50% addition), or an 850/1200 rpm (a 50% addition) motor. This speed increase over base speed is accomplished by reducing the field voltage, which reduces the wall or base against which armature current can react, thus reducing the available torque (non linearly) with reduction in field voltage, even though the armature current may be a nameplate value.

At a base speed or in the field regulated range, the drive can produce only nameplate hp. Thus, with a given resin, we can only speed up the motor above base speed if we were not utilizing full nameplate armature current or full torque of the motor at nameplate rpm. Even so, this is a highly useful tool in two very common conditions. First, when there are two resins to be run with significantly different torque and screw speed characteristics, such as ABS and HIPS, or HMW HDPE and LDPE on the same machine, or second, to better match a drive capability with available extruder gear ratios. Thus, an ABS machine could utilize a 250-hp, 11/50/ 1750 drive belted for 1750 motor rpm = 150 screw rpm for use on HIPS, and it would run the ABS to around 100 rpm before running out of torque, or HIPS at 150 rpm before running out of speed.

There is one side benefit of the low base speed/field regulated drives; namely, a better power factor throughout the field regulated operating range.

AC Variable Frequency Drives AC variable frequency ("Vector duty") drives have become a very cost effective competitor to 1750 rpm DC drives through 100 to 150-hp on a first cost basis, and at even higher hp's when long term operational costs are considered.

These drives utilize a regulator to convert 3 phase AC power to DC, then reconvert or "chop" the DC back to 3 phase AC having a somewhat "square" VS sinusoidal wave form. The drives require a special AC motor, a "high efficiency" or "Vector" duty motor, insulated adequately to accommodate the high voltage spikes to which they are subjected by the "chopping" action of these drives. The advantages include 0.2% or better regulation without an expensive DC tachometer, 0.0 1% regulation with an encoder. Further, they have a better power factor over the low speed range than the DC drives, as there is not the long delay in firing the SCR’s to create a low DC voltage, and utilization of brushless (therefore low maintenance) motors. They have operational ranges of 1000:1 with an encoder, and 20 to 100:1 without one. They are constant torque motors up to the base speed, so the nameplate hp is at the nameplate frequency. The 1750 base speed motors can be operated in an "extended range" of up to 3500rpm, thus they have what equates to a field regulated range on a DC motor with the same decreasing torque characteristic. Unfortunately, low base speed (1150 or 850) rpm "Vector duty" motors have not become widely available at competitive price and delivery, thus limiting the hp range to that required by extruders generally below 4-1/2".

In summary, the costs and benefits of both AC and DC drives should be considered for extruders, weighing the degree of breadth of the torques and speeds the drive will have to deliver, the long term maintenance costs, and the value of a moderately high power factor in the specific application.

- Donn Lounsbury Davis-Standard

See also:

- AC drive update
- AC variable frequency drives
- Calculating DC drive power
- DC motor maintenance
- Drive overload
- Measuring RPM

Return to Consultants' Corner