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Application Note
Injection Molding

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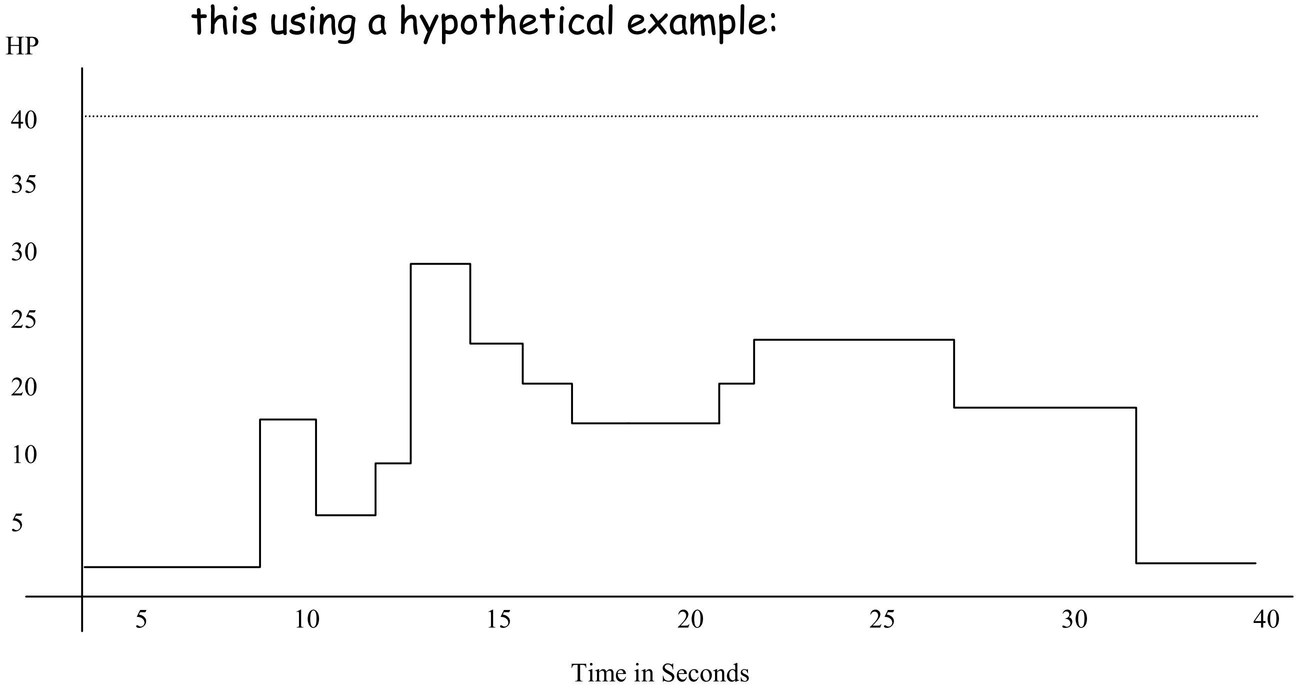
I. **General:** Brushless Drives are uniquely suited to two specific applications in injection molding machines. Number one of these is the hybrid modification to the basic hydraulic machine, where a brushless drive replaces the original constant speed AC motor. The second is the total electrification of the machine where all axes are controlled directly by variable speed motors rather than hydraulic actuators. The purpose is twofold. The all-electric machine can make more parts in less time at less energy cost, but the initial capital cost is substantially higher. The hybrid machine maintains the hydraulic system and changes the speed of the motor to flow only the hydraulic fluid needed for each cycle rather than bypass the extra flow through a pressure relief valve. This application note will specifically address the hybrid application. There are some patent issues in the use of variable speed, and in some cases, Brushless specifically on Injection Molding machines. Those involved in selling or retrofitting machines should become aware of those. The specific examples discussed here are based on hydraulic machines where fixed displacement pumps are used. Variable displacement pump machines have a patent by a major manufacturer of machines restricting Brushless use.

II. **Energy Savings:** The reasons to convert a pure hydraulic machine to variable speed are based on energy savings. Where do these savings come from? They come from having the hydraulic pump run only fast enough to produce just the flow required by the machine at each point in the cycle of making a part. For this example, it is assumed there is no accumulator on the machine and that the pump is constant displacement rather than variable displacement. The constant speed motor typically used on the older machines, of course, runs the pump at the same speed (therefore same flow) ALL the time, not just some of the time. As a result, the system runs at too great a flow and the extra pressure that results is valved back off to the oil reservoir and this all represents lost energy. As an example. Let us say that during the injection cycle, the rated pressure (say 1500 psi) is needed at 5 gpm flow. The pump may be sized for say...40 gpm when the AC motor is running at full speed. Furthermore, if the motor is sized such that at 1500 psi, 40 gpm the HP from the motor required is 100 hp. If the flow can be reduced to 5 gpm, by a variable speed motor, then the actual HP delivered by the variable speed motor would be only 12.5 hp instead of the 100 hp being delivered by the constant speed motor, saving 87.5 hp for that part of the cycle. Looking at this using a hypothetical example:



Referring to the example above, consider the dotted line as representing the constant flow, constant pressure produced by the AC motor running at constant speed. Any flow not required by the hydraulic actuators on the machine would be valved back to the pump reservoir; therefore the power consumed is 40 hp all the time. The solid line represents the power actually used by a variable speed drive capable of very fast speed changes to keep the flow only at the level required for each part of the machine cycle. Averaging all the HP values in the cycle over the time for the cycle might be 10 HP. In this case the energy usage for the machine running this part continuously would be 30 hp (75% savings). Such savings on real machines in real applications are practical and expected. Of course the actual savings depends on the specifics of the machine cycle. For instance, a large part with long cooling times will result in greater savings, since in the cooling part of the cycle virtually no energy is used by the variable system other than it's own cooling fans and power supplies because no hydraulic flow is present, only static pressure.

Lesser savings can be had with machines using accumulators and/or variable displacement pumps, but the potential savings even on those type machines it very high.

III. What are the drive requirements? Virtually any kind of variable speed drive can be used, but the secret to the greatest energy savings is the ability of the drive to accelerate/decelerate quickly to make the flow keep up very closely with the actual demand and the ability of the controller system used to characterize the machine operation.

a. If the drive accelerates and decelerates slowly, then the speed to produce the desired flow must be commanded well before the flow is needed to allow the drive to reach the peak flow needed when it is needed. The extra flow produced during the accel time is all energy loss, since the flow is not actually needed by the machine. The same happens on deceleration. If the drive cannot slow down very quickly, then it must wait until the high flow is not needed, then slow down to a new lower flow slowly. This extra flow is all energy loss. Even if the motor can accel and decel rapidly, if the motor has significant inertia, then energy will be put into accelerating and decelerating the inertia and that energy will also result in pure energy loss.

b. The controller telling the motor what speed to run at each point in the process needs to establish as many predetermined time-sliced speeds as the machine has "spikes" of flow needs. The more closely the controller (usually a PLC) commands the right speeds to match the actual machine requirements at each point in the cycle, the more energy is saved.

IV. **Why Brushless?:** Brushless motor/drive systems are the most efficient variable speed drive technology available. With no slip required for operation, efficiency is typically 3 points better than the best vector induction motors. Power factor and harmonic currents from the AC line are virtually identical in a vector induction drive and a brushless drive. Additionally, brushless motors have much lower inertia than induction motors (or DC motors for that matter), making the system much more able to track the machine flow requirements without wasteful early acceleration and late deceleration to new flow rates. An OEM customer using our Brushless motor/drives ran a head-to-head test of AC vector vs Brushless on the same machine running the same part and found that the Brushless used 30% less energy than the vector system. In other words, the vector system saved approximately 55% of the energy used by the constant speed motor, but the Brushless system used only 38% of the energy used by the constant speed motor. As a final point, brushless motors are small and light compared to AC motors. A 100 hp standard Baldor Vector motor is in a NEMA 405T frame, and weighs 1166 lbs, with a rotor inertia of 27 lb-ft2. Whereas the Powertec Brushless 100 hp motor is in a NEMA 259T frame, weighs only 400 lbs and has only 3.8 lb-ft2 inertia. Powertec also has a series of standard adapter flanges to directly mount either a single hydraulic pump on the normal drive end of the motor, or two hydraulic pumps, one on EACH end of the motor. This was a fairly common configuration on older machines of high tonnage capacity at this HP level. This makes the mechanical installation on the machine very easy.

Contact Powertec Industrial Motors for more information or contact us at sales@powertecmotors.com.