Conveying Savings via Variable Speed Drives

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In-plant central resin conveying systems have been designed and installed based on one overruling factor: the highest demand for the longest-distance conveying run. Typically, virgin raw material is supplied from outside silos or bulk trucks and is also the highest-usage material, so the conveying line size is chosen and the vacuum power unit is specified accordingly. Other ingredients could be supplied from nearby day bins and/or Gaylord boxes, and minor ingredients could come from barrels or boxes right next to the machine. For a central conveying system sized for the highest-demand materials and longest conveying runs, conveying additives and minor ingredients can cause damaged resin and angel-hair formation, excess energy usage, and oversized conveying lines and pick-up wands for these ingredients.

The use of a variable speed (or frequency) drive (VFD) for non-traditional applications is becoming more and more commonplace. Almost every traditionally fixed-speed system in the plant is now being offered with a variable-speed drive option or upgrade, such as air compressors and water-cooling systems. The vacuum pump used on your central conveying system is no exception. The use of a variable speed drive will address all of the issues outlined above and more. This article will explain how each problem area is addressed and review costs and payback for a typical VFD upgrade.

Line & Pump Sizing

By knowing the resin type and associated coefficient of friction, the conveying distances and number of elbows, and the required maximum consumption rate, an engineer can determine the ideal line size for the application. Based on the required conveying pickup velocity (typically 4,000-5,000 ft/min), a line size-specific vacuum pump can be sized by calculating the resulting air volume and maximum vacuum.

While doing calculations for an in-plant system, the engineer may come up with different ideal line sizes and pumps for various conveying runs: for example, 3-inch lines with a 10-hp vacuum pump for virgin material; 2-inch lines with a 5-hp pump for additives; and 1.5-inch lines with a 2-hp pump for minor ingredients. In a typical in-plant system with a fixed speed vacuum pump, all ingredients will have to be conveyed through 3-inch lines and with 10-hp worth of vacuum/conveying air. This is where the damage to the resin and energy waste occurs, with a much higher-than-necessary conveying velocity for lower-demand and shorter runs.

It is at this point where the advantages of a VFD for the vacuum pump become clear. By being able to program a unique pump speed for each station on the central system controller, the ideal conveying velocity can be established for each run: long, intermediate, and short (see *Figure 1*). This will eliminate the chance for material damage and reduce the energy consumption for the system.

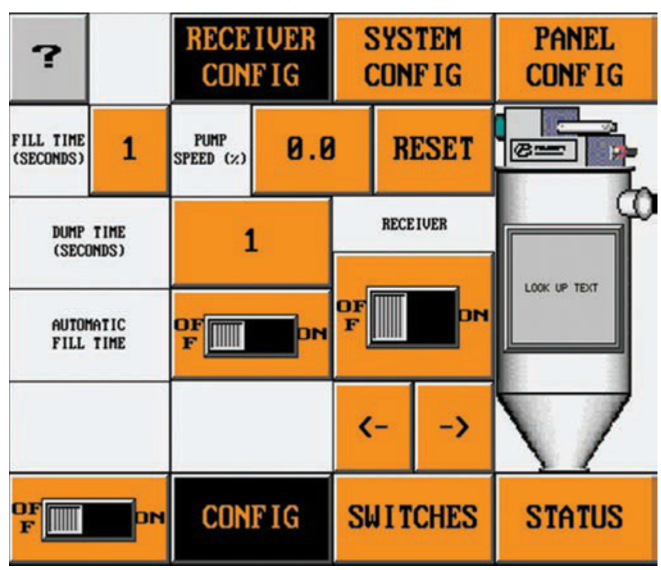

Figure 1: Vacuum receiver configuration screen on PCC Director™ sequencing panel to control pump speeds for each station

Testing for Savings

To confirm how much energy could be saved for a typical retrofit of an existing system, we configured a conveying system consisting of three different sized Guardian 2 batch blenders, with three elements each (see *Figure 2*).

Figure 2: Guardian 2 batch blenders with VFD conveying system setup in showroom at PCC in Atlanta, Georgia, USA

A 25-kg blender was configured to run at 1500 PPH (pounds per hour; 680 kg/hr) with the longest conveying distance, a 12-kg blender running 1400 PPH (635 kg/hr), and a 5-kg blender running 550 PPH (249 kg/hr) with the shortest distance. The conveying system was configured with 3-inch lines and a 10-hp pump (76 mm and 7.5 kW), and also included a continuous run valve on the inlet of the vacuum pump. The continuous run valve is used for short idle times between conveying cycles to allow the pump to continue to run while pulling air in from the atmosphere. This avoids the wear and tear and motor load spikes caused by frequent starting and stopping of the vacuum pump motor.

Six eight-hour tests were then conducted: three with the pump at full speed and three with the pump programmed with reduced speed, based on the ideal conveying velocity for each run. Furthermore, for the three reduced-speed tests, the pump was set to 30% speed during the idle time, utilizing the continuous run valve. The only thing that changed between the runs was the blender ingredient percentages, to give some variability to each.

As measured by a kilowatt-hour meter, the energy saved by reducing the pump speed ranged from 36% to 46%. Depending on the exact system configuration, hundreds or even thousands of dollars in energy costs can be saved every year with the VFD.

The approximate cost for upgrading a 10-hp vacuum pump with a VFD is $5,000 (US), including upgrades to the control package. When installing a new in-plant system versus retrofitting an existing system, you have the opportunity to install smaller conveying lines for intermediate and short runs. This mix-and-match approach will help offset the VFD investment by reducing the cost of the tubing and hardware. We calculated the tubing cost for a typical in-plant system using all 3-inch lines at $7,350, and recalculated the cost, based on 3-inch lines for the long runs, 2-inch for the intermediate runs, and 1.5-inch for the short run, at $5,800, for a savings of just over 20%. This configuration will further enhance the handing of the system by using smaller hardware for the shortest runs, such as vacuum hoses and pick-up wands, which can be very cumbersome in larger sizes. Further energy can be saved by the reduction of line size as well.

Recommendations

We are now recommending the use of variable speed drives for the vacuum pump on all central conveying systems quoted to customers. Especially when the VFD cost can be offset by reducing the tubing and hardware costs, energy savings can result in payback periods of a few years or less. Further cost savings may be had through the power companies, who sometimes offer incentives for the installation of energy-saving technologies.

Benefits of the VFD are not limited to the in-plant system, but can also be used on bulk truck and railcar unloading systems. Railcar unloading systems can have extreme variations in conveying distances, having to unload cars all along the rail spur. Like the in-plant system, the pump package has to be sized for the worst case, which is typically unloading the farthest railcar in eight hours or less. When conveying from the nearest car, the energy loss and damage to material due to high air velocities can be quite significant. The control technology exists to look at conveying conditions at the beginning of the unloading cycle and automatically tune the pump package for optimum performance.

About the author: Dana Darley has been the general manager of Process Control Corporation in Atlanta since 2008. He is also founder and president of Extrusion Auxiliary Services, Inc., and has been working in the extrusion industry since 1981. Dana holds a BS degree in Mechanical Engineering from Clemson University, and has authored numerous articles and technical papers on auxiliary equipment.