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Managing Power with Variable Frequency Drives

Professional car wash companies have to position themselves to capitalize on available technologies to mitigate utility costs. The focus of this paper is to present the science and benefits of using variable frequency drives (VFDs) within your motor control system.

Changing labor and immigration law at the end of the century encouraged the car wash industry to overcome the inertia of dependence on manual processes to clean and dry cars. Once in motion, we have been quick to increase operational effectiveness through automation. New machines have replaced manpower with horsepower. Today, it is not uncommon for a car wash to require a 460VAC 600 ampere electrical service to power wash processes. Unfortunately, we have not embraced power management along with power consumption. Now the professional car wash industry is faced with the reality of eroding margins from ever-rising electrical costs powering increased levels of deployed automation.

The case for potential electrical savings at the car wash is well documented. A U.S. Department of Energy Study reported that 63 percent of the power produced in the United States is used to operate motors, and of those motors, 60 percent operate pumps and fans[1]. The resulting Motor Challenge from the study set a specific goal to increase the market penetration of energy-efficient industrial electric motor-driven systems by helping industry adopt a systems approach in designing, purchasing, installing, and managing motors, drives(variable frequency drives), and motor-driven equipment such as pumps, fans, and compressors[2]. A paper presented at the European Commission Conference: 'Energy Efficiency Improvements in Motors and Drives" 1996, Lisbon, Portugal corroborated the US Department of Energy study and states that the potential US energy savings in system improvement by 2010 are very large - over 100 billion kwh/year through improved sizing and proper matching to load, use of more efficient drive trains, improved system layout, updated and well-maintained controls, improved operation and maintenance, and use of Variable Frequency Drives (VFDs). Today, it is not uncommon for an automatic car wash to operate a dozen or more motors powering pumps, fans and compressors; multiple 20-25HP pump stations and central vacuum systems, 150HP drying systems, 7.5HP air compressors, recirculation and re-pressurization pumps for reclaim systems and heating systems, etc. Car washes are perfect candidates for implementing the recommendations from

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[1] US Department of Energy Study

[2] Scheihing, Paul E. U.S. Department of Energy, Industrial Technologies Program Washington, DC, USA U.S. Department of Energy's Motor Challenge Program: A National Strategy for Energy Efficient Industrial Motor-Driven Systems

the study, the motor challenge and the European Commission's paper. US industrial users have embraced the power of VFD's and now regard their use as standard design elements for fans, pumps and compressors. "End-users know or should know that VFDs produce energy savings. One of the biggest ways comes from optimizing motor speed and demand, applications that benefit the most from this would be fans, blowers and pumps. Without a VFD, the motor would run at full speed all the time."[3] We in the car wash industry are well behind other industries in adopting the recommendations. The good news is that we are sitting on huge savings waiting to be mined.

Let's start with basics. All 3-phase induction motors are designed to operate at one speed; typically 1200, 1800 or 3600 rpm. Since the electric utility provides power at 60 cycles per second (Hertz), motor speed is determined by winding configurations within the motor. As a result, equipment driven by induction motors (including dryer fans, vacuum fans and air compressors) are constrained to a single speed. A VFD, on the other hand, allows nearly all induction motors to vary speed. The 60 Hertz power from the electrical utility is converted to DC power. Modern VFDs[4] then send pulses of varying width and polarity to the motor. The result is a motor that can now be operated at any speed between 0 and 60 Hertz. A VFD is like a big dimmer switch for motors. It can increase or decrease motor speed as needed depending on the work required of the motor. There is no sense running a motor flat out 100% of the time if only 50% of its capacity is required.

Although VFDs can produce energy savings on many different equipment loads, car wash dryer fans, pumps and compressors offer some of the greatest potential savings. This is the result of the Affinity Laws, which govern the flow, pressure, and power requirements of a fan or pump in a closed, un-damped system:

- Air Flow - Fan Speed
- Pressure increase - Fan Speed^2
- Power consumed - Fan Speed^3

Dryer fans in a car wash are a classic example of these laws that offer nearly perfect cubic power reduction with speed. This means that a fan operating at 50% speed will ideally draw 12.5% shaft power. Although motor and drive efficiency might temper this ideal value to the range of 15%, the 85% power reduction is tremendous. To top off the fan energy reduction, VFDs also eliminate demand spikes and electromechanical torque stress. Additional savings are captured in lowering utility demand billing rates[5] and increasing the longevity of electrical and mechanical components.

To benefit from VFD motor control, the VFD must be programmed to change the speed of the motor when full speed is not required. For example, one way to capture dryer fan savings comes from slowing the motors down when no vehicle is present. Simple motor starters keep motors running flat out waiting for

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[3] Amos, Kenna C., VFDs Reduce Wear, Save Energy, Automation World, October 2008

[4] O'Kane, Matt, VFD Drive Technology Can Save Over 30% In Energy Costs. If we look back just 15 years ago, the reputation of AC drives as a reliable and cost effective method of variable speed control was poor at best. The technology offered consisted mainly of analog controls and SCR (Silicon Controlled Rectifier) power devices. The AC products on the market at that time, for the most part, were physically large, expensive and unreliable. In recent years, the technology of AC variable frequency drives (VFD) has evolved into highly sophisticated digital microprocessor control, along with high switching frequency IGBTs (Insulated Gate Bi Polar Transistors) power devices. This has led to significantly advanced capabilities from the ease of programmability to expanded diagnostics.

[5] U.S. Department of Energy, Office of Industrial Technologies; Energy Management for Motor Driven Systems. Demand is a charge based upon your maximum or peak rate of energy use. A typical demand meters averages demand over a specified "demand interval", usually over 15 or 30 minutes continuously. In this instance, short periods of intense use, such as a ten-second startup of a motor, have little or no effect on demand; (unless motors are continuously turning on and off, like in a car wash during off peak hours). A few utilities base their demand charge on a facility's instantaneous peak. In this case, periods of intense use can significantly affect demand. Each car wash needs to understand their rate structure to determine whether or not demand charge reduction represents potential savings for their operation.

vehicles and in between vehicles. However, using the tunnel controller to identify when the vehicle is not present in the drying zone, a VFD can reduce dryer fan motor speeds generating huge savings; see table below.

Results below were obtained from monitoring the performance characteristics of a dryer system consisting of 17 fans @ 10HP per fan being controlled by one 200HP Variable frequency drive @ 460 VAC[6].

Sample One Motor Speed is 97.7% of full speed or 58.6 HZ

Output Power Factor	Output Current	Output Frequency	Output Power	Output Voltage
0.87	218.8	58.6	147.3	449.6

Sample Two Motor Speed is 89% of full speed or 53 HZ

Output Power Factor	Output Current	Output Frequency	Output Power	Output Voltage
0.87	185.12	53	113.9	406.2

As you can see, the speed was reduced from sample one to sample two by 8.7%, but the output current dropped by 16% and the output power dropped by 23%. Power is the rate of energy use. The amount of energy used by a motor driven system is directly proportional to the power draw of the system times the length of time it is in operation. Energy consumption from lowering the fan speed 8.7% generated a 23% reduction in energy consumption for as long as the dryer speed was allowed to remain at 53 HZ. Consider how much time per year the dryer speed could be lowered between cars or during "Look Back" generating savings.

Variable frequency drive (VFD) technology is a powerful technology for car washes but often misunderstood and misapplied. If misapplied, the additional acquisition cost of the technology delivers unsatisfactory ROI and will dissuade operators from its future implementation. Anyone that has had a bad experience with VFD technology in the car wash industry is likely due to inexperienced suppliers misapplying the technology or the operator not understanding how to manage power to generate savings. As you investigate the potential savings you may be able to achieve at your car wash, contact automation professionals that can help you identify and implement known applications that help you better manage your power[7] at the car wash using VFD Technology.

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[6] Rockwell Automation and Smartstartra; Power Monitor VFD Testing, Dallas, Texas, January 2009

[7] Power Management is the proactive management of your power consumption. The first step toward effective power management is to be a well-informed energy consumer; know how much power you use, what your major loads are, when you use electric power the most, and how much you pay for it. It's also important to understand the quality of the power you use. Once you understand your power, then you must actively seek out and implement power saving technology and optimize its use.