White Paper

Integrated Drive Systems

Increase profits with optimized products and processes

Increased productivity, higher energy savings, reduced operating costs and lower carbon footprints are now available to large industrial systems running fans, pumps and compressors – especially in oil and gas, cement and mining industries.

These and other industries are electrifying their processes to increase precision process control for higher efficiencies, lower total cost of ownership and reliable systems. Each industrial process has a corresponding application. Each also has unique differences because of site and process conditions. As a result, industries are turning to engineered to order (ET) solutions.

ETO solutions are further enhanced when the motor and drive system design is based on standard technology and products, thereby reducing lead times for engineering, manufacturing, procurement and spare parts.

When selecting individual components for an Integrated Drive System (IDS), industries have significant opportunities to improve the overall performance and reliability their operations.

IDS adds significant value to any company by lowering the total cost of ownership. However, if a motor and drive system is not properly optimized downtime and expensive repairs will almost certainly influence the bottom line.

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Introduction

Power Electronics – New Opportunities and Problems

With the advent of power electronics, industries are taking advantage of new opportunities to improve drive system performance. Variable Frequency Drives (VFD)* can increase operating efficiency, accelerate higher inertia loads, lower starting current draw, reduce transient torques on startup and more. The end results are impressive and include reduced lifetime costs, increased functionality and improved reliability.

As more components work together throughout a larger speed range, proper coordination is required to avoid negative impacts when operating as a system. Power electronics tend to distort the incoming power due to line notching and distortion of the fundamental sine wave. This distortion, and its associated harmonics, may cause unwanted heating in transformers and motors attached to the power line. Voltage spikes from these power electronics may enter into motors and transformers and overly stress the insulation systems as well.

When the requirements and functionality of the drive system are well defined, optimized components can be selected or designed to achieve highest reliability and lowest cost of the entire system package. The total cost of system ownership can, and should, also be reduced when drive train components such as motors and VFDs can be selected, designed and sized to work together as systems. We will provide examples of the improvements in component size and cost when they are sized together as one package, as opposed to having each component sized separately without consideration of the other components.

What is Integrated Drive Systems Engineering?

A typical drive system is made up of a VFD, a motor, a coupling, the driven load, and often times a gear box; some or all of which may be mounted on a common foundation base. Each of these components has potential failure modes, and it is important to evaluate and design the components to avoid premature failures that can lead to overall system failures. To optimize the cost of system packages, the cost drivers of each component and their sub components must be evaluated. Based on the relative cost differential between the components and design parameters which influence them, the optimized sizing of components for lowest cost and highest reliability can be achieved for the system requirements. While each component individually is commonly referred to as a product, the integration of these components toward a lowest cost and highest reliability solution can be referred to as an Integrated Drive System (IDS). However, it is important to understand that if the products are not properly integrated into a system, it may become a huge risk and liability ranging anywhere from a delay in project startup to total system failure. Integrating components requires product, application and system level expertise.

* Variable Frequency Drive (VFD) may be used interchangeably with adjustable frequency drive (AFD).

Benefits of Integrated Drive Systems Engineering

There are several benefits of IDS engineering, including:

A) Total Cost of Ownership

Total cost of ownership has two major parts: First is the initial product cost, and second is the total operational cost over the life of the system. By creative IDS engineering, one can substantially improve both of these parts.

Here is an example for initial cost reduction: The following figure shows the variation of relative cost of motors and drives with power. There is potential to reduce the overall system cost by reducing the cost of the more expensive component and allowing a minor increase in the cost of the less expensive component. One must understand that the motor's cost is normally power limited. However, the drive's cost is related to its voltage and current limits, and not necessarily related to its power output. In the common application of various products over various power ranges, the cost per horsepower can be minimized when the ratings are at the maximum available potential for each of the components.

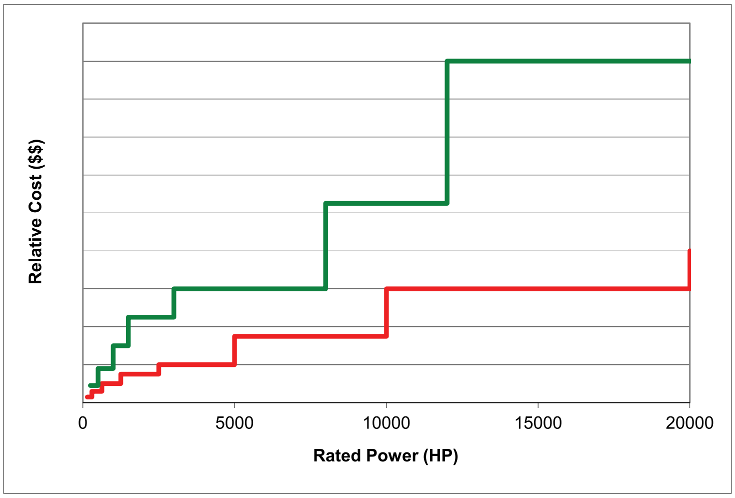


Figure 1 Frame Cost Break Down of Motor and Drives

As can be seen in Figure 1, the relative costs of the motor and drive have certian break points where the cost jumps significantly at specific horsepower thresholds. This situation is common when producing somewhat standardized components with discrete frame brakes. However, optimization can also be harnessed when cost breakpoints are aligned with particular care. Significant cost benefits can be seen in the initial capital investment. This may be further applied to the driven load and the power system used in the facility.

To be more specific, it can be shown that there are certain cost breakpoints or power ratings, where it becomes more advantageous to increase the operating voltage. To illustrate this, let us consider an application where it is advantageous to evaluate the maximum output voltage and current capability of the drive when sizing the motor and drive together. By evaluating the total cost of the motor and drive together, the respective costs can be further minimized. In one case, it was observed that selecting a motor to operate at the drive's maximum output voltage of 8,010 V (rather than a conventional 7,200 V) resulted in a significant reduction in motor current draw, I2R losses, required size, and, ultimately, initial cost. When sized for conventional voltage ratings, the shaft power was limited to 18,000 HP. Now, at this higher voltage, the motor is capable of delivering 20,000 HP without having to jump to a synchronous motor, which could double the cost in some cases. In addition, the drive was also limited to the same current that would have forced the use of two drives in parallel. As a result of proper IDS engineering, the overall cost could be reduced by nearly 50 percent by optimizing the package.

Energy savings can be realized if the operation of the process is understood. The system integrator will need information about loading points and duration of loading to be able to choose parts of the drive system to achieve the highest efficiency and reliability. In general, for pump applications, flow can be controlled mechanically from the pump by using valves (bypass or throttle) or by speed control of the prime mover. There is substantial cost savings from energy conservation whenever the required flow quantity is below 90 percent of maximum flow.

We will now illustrate the energy savings resulting from applying Siemens Integrated Drive Systems to a 2,000 HP, 1,800 RPM system, which includes a pump. The pumping process here has variable flow requirements, as shown in Table 1. As seen from the energy cost calculations, the annual cost of operating this variable speed motor is 30 percent of the cost to run a fixed speed motor.

Table 1

2000 Hp, 1800 rpm Variable Flow Pump Operation, 365 days 24 hrs/day			
Flow	Duration	VFD-Motor	Valve Control
25%	10%	$1,573	$66,375
50%	60%	$75,750	$494,381
75%	20%	$84,970	$104,964
100%	10%	$98,606	$104,964
Total Cost / Year ($0.07/kWh)		$260,680	$853,402

B) Reliability

Drive train reliability can be increased by properly understanding the application requirements, knowing the site's environmental conditions, correctly sizing the equipment and understanding the interaction between the various components when they are integrated together to build the system. One of the most common reliability issues is lateral and torsional vibration in a complete system due to resonances. To avoid vibration issues, the components should be selected and sized so there is sufficient margin between excitations from components and the natural frequency of the integrated system. Based on the application and site conditions, couplings with proper radial and torsional stiffness could be selected which are often more resilient to misalignments between the driven and driver. Ambient temperature swings or loading conditions also affect the performance of a drive system. In many indoor applications with climate control, special considerations are not required to ensure proper alignment and low vibration throughout ambient temperature swings from cold to hot.

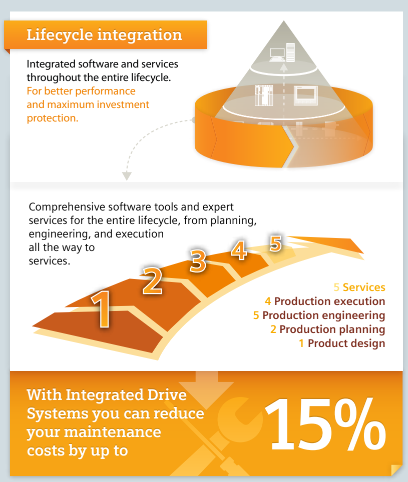
In many cases, a hot alignment may be needed after the motor, driven equipment or gearbox heat up to full operating temperature. It is not uncommon for these components to grow vertically or move horizontally at different rates relative to temperature. Variations in alignment of the shaft centerlines of more than .020 inches or .040 TIR (Total Indicated Runout) have been observed. The solution of hot aligning has been practiced for many years to correct this issue. This is well outside the normal allowance of .002 TIR. As a result, special considerations and components must be addressed.

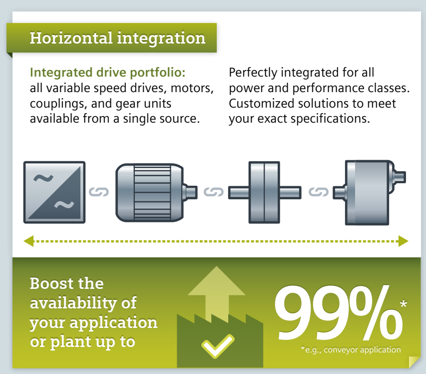
Another concern is when the system is used outdoors with wide ambient air temperature swings. When the motor and gearbox are not cooled by the same medium or are not of equal height to their respective foundations, they will not grow at the same rate as a result of the ambient temperature swing. No matter the climate, there is always the potential for large ambient swings. Any differential between coupled machines must be considered and addressed. The supplier needs the product and application knowledge to properly design the entire system to solve these kinds of ambient air and temperature problems with products including flexible type couplings, for example.

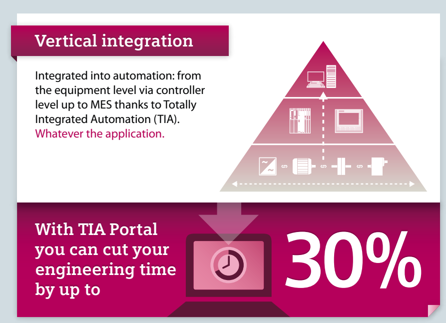
Conclusion

IDS allows end users to consider the drive train as a single purchase. Engineering, modeling and analysis by one supplier to match the dynamics of the mechanical equipment allow the system to work in harmony. End users' design specifications are optimized for performance and save a significant amount of project startup time.

Business processes associated with purchasing drive train components are streamlined. Each component meets or exceeds technical specifications. System performance, reliability requirements and economic directions are always met. Every mechanical fit is validated, as are environmental and performance specifications.







Notes

Notes

The information provided in this white paper contains merely general descriptions or characteristics of performance which in case of actual use do not always apply as described or which may change as a result of further development of the products. An obligation to provide the respective characteristics shall only exist if expressly agreed in the terms of contract.

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