Integrated Drive Systems (IDS)

Optimized for lower costs, higher performance and maximum reliability

Optimization has been defined as an act, process or methodology to make something as fully perfect, functional or effective as possible. No matter the industry or application, optimization reduces the total cost of ownership, boosts reliability and increases performance of any product, system or service.

Siemens Integrated Drive System (IDS) is the leader for optimized drive systems around the world.

IDS evaluates the cost drivers of each drive system component – as well as sub-components, scrutinizes design parameters and considers optimal component sizing. This upfront examination requires Siemens' unsurpassed levels of product, application and system expertise.

By defining the expectations, requirements and functionality of the drive system, all IDS components seamlessly work together to deliver the lowest system cost, highest reliability and best performance. The end result is an optimized system consisting of an variable frequency drive (VFD), motor, coupling and sometimes a gearbox – each or all of the IDS components may be mounted on a common foundation base. Siemens also seamlessly integrates all other IDS components including switchgear, transformers, controls and drive/control enclosure to ensure they all work properly together.

This optimized drive train is increasingly popular in large industrial systems due to its high system efficiency, operational flexibility, reliability and reduced carbon emissions.

Answers for industry.

The alternative to IDS, or not properly integrating the drive system components together, may delay project startup, cause frequent process interruptions or total system failure.

Lowering the cost of ownership

Siemens IDS lowers the total cost of ownership because the drive system components, starting with the VFD or switchgear and ending with torque or power out the shaft, are designed and sized to work cost efficiently together as a system.

It's no secret that in most cases VFDs account for a majority of the initial cost of a motor-drive package. IDS lowers the cost of a VFD since the motor and the VFD's power cell configuration are designed to complement each other. Siemens motors are custom designed to accept non standard voltage inputs to deliver maximum system performance and cost reduction while continuing to meet all design specs.

Siemens carefully considers the motor operating current and motor operating voltage to optimally size the VFD. These parameters help determine the different product lines, types of cells and the number of cells required in the VFD. A properly sized VFD symbiotically fits with the motor and other system components.

Siemens custom motors are engineered to minimize full load current and VFD cost. Voltage is reduced to minimize the number of power cells. As a result, the overall system cost is reduced. While minimizing the current may require raising the motor voltage to satisfy power requirements, this can also reduce the size of the VFD without affecting the drive input voltage. Though the motor cost may increase a small amount, the difference is normally small compared to VFD savings.

Understanding the process

Over the life of the system, energy savings can also be realized if the operation of the process is understood.

Consider an end-user who purchases a motor and an VFD from two different manufacturers. The 3,000 kW system operates at 91 percent efficiency under rated load. Because the motor and VFD were not necessarily designed for optimal operation with one another, there are additional harmonic losses induced in the system. Although they may reliably operate together, the drive system efficiency deviations would add energy costs over the life of the drive system.

Drive system operating half of the time under continuous duty at ***91 percent*** *efficiency with an average energy cost of $0.09 per kWh would cost approximately $1,300,450 per year.*

$$\frac{3000\ kW}{0.910}\ \frac{4383\ hrs}{yr}\ \frac{\$0.09}{kWh} = \frac{\$1,300,450}{yr}$$

Figure 1 Yearly Cost at 91 Percent Efficiency

IDS ensures that both the motor and VFD are designed to operate with one another through mitigation of electrical losses. The 3,000 kW IDS is observed to operate at 92 percent efficiency under rated load, making it one percent more efficient than the non-IDS.

Drive system operating half of the time under continuous duty at ***92.0 percent*** *efficiency with an average energy cost of $0.09 per kWh would cost approximately $1,286,315 per year.*

$$\frac{3000\ kW}{0.920}\ \frac{4383\ hrs}{yr}\ \frac{\$0.09}{kWh} = \frac{\$1,286,315}{yr}$$

Fig. 2 Yearly Cost at 92 Percent Efficiency

This comparison yields an average savings of $14,135 per year for the life of the system. Furthermore, greater efficiency can be obtained from the IDS design by oversizing the transformer or designing the motor-VFD system to use the least amount of current to produce the required power to the customer. However, these methods may increase the initial capital cost of the system. Therefore, the tradeoffs between initial capital cost and the returns from efficiency savings will need to be evaluated before design changes are implemented.

These energy savings are an added benefit to the much larger savings normally seen when speed is used in a motor/drive package to throttle down the output verses the closing of valves, vanes or dampers on pumps, compressors or fans.

Enhanced reliability

Historically, end users have had little choice but to accept the responsibility of ensuring all drive components work properly together. This includes all specifications and coordinating information among suppliers. When a failure happens, suppliers blame each other. When requirements are not clearly communicated, the integrator or end user will be on the hook for repairs and perhaps warranty litigation.

Siemens assumes these responsibilities in every IDS. The result is a long, reliable drive system life.

Siemens also ensures that damaging harmonics are not transferred back to the system. These harmonics create additional losses or hurt the performance of other machines running on the same power system. They can even create shaft currents in other product not running on a VFD that would not normally see this concern.

This drive train reliability confidence begins with Siemens' thorough understanding of application requirements, site environmental conditions, correct equipment sizing and the interaction between components.

For example, lateral vibration is a common reliability issue. To avoid vibration problems, Siemens sizes and selects each component for sufficient margins between excitations and the natural frequency of the system. For higher reliability and longer life of rotating mechanical equipment, the vibrations of individual components and the entire drive system are engineered as low as possible for the entire speed range.

Induction motor shaft currents also result in reliability problems relating to bearing failures. A number of issues can cause shaft currents; however, they often result from either magnetic field dissymmetry producing a voltage along the length of a motor rotor shaft or common mode voltage resulting from a capacitive current flow through all bearings in parallel.

The dissymmetry and resulting shaft currents also increase with higher frequencies produced by the high frequency switching of the VFD. The voltage will force currents to flow down the shaft to ground through the bearings causing the bearings to fail in a short period of time. When a non-insulated coupling is used and voltages that lead to shaft currents exist, the current can flow into the driven equipment and then through the driven equipment's bearing to ground. In this application, the motor is well protected but driven equipment bearing may still fail.

Even the most knowledgeable engineer may find shaft current issues overwhelming, not to mention coordinating with multiple vendors. Siemens addresses all shaft current concerns and considers all the pros and cons of the possible solutions.

Voltage stresses cause even more reliability headaches. Semiconductor devices switch on and off in milliseconds, causing motor terminal voltage spikes with extremely fast rise times to abnormally high peak voltages. These spikes harm a motor's insulation and shorten its lifespan.

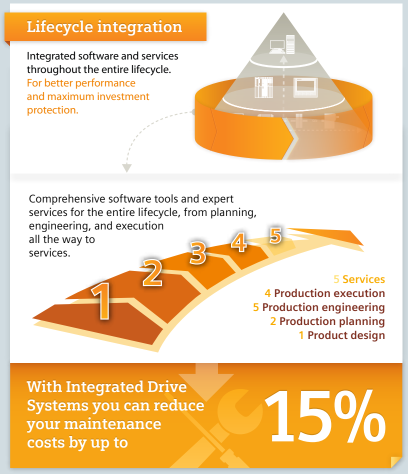
Siemens designs the VFD to be in sync with the motor, eliminating the need for the end-user to be a system expert. Peak voltages and levels coming out of the drive never exceed the design capability of the motor's insulation. The reliable solution may involve changing the VFD topology, adding insulation on the individual turns of a coil or to the ground wall insulation to reduce voltage stress level on the insulation between turns, between phases or phase to ground on the motor.

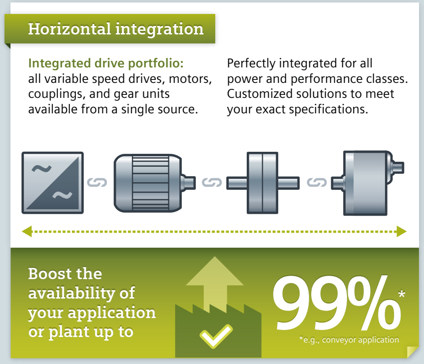
Efficient performance, better availability

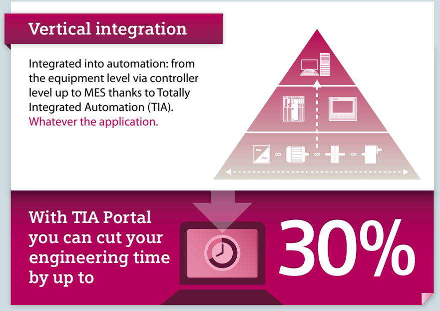
IDS efficiency is the touchstone of the design process. The motor accommodates a particular drive output to mitigate drive system losses and establish optimal drive system efficiency. Defined, drive system efficiency is the ratio of output power produced out the shaft to the input power from the power system. Siemens understands the factors that influence motor and VFD efficiencies.

Global standards working groups are establishing system efficiency levels and ways to measure total system efficiency in EN 50598 and IEC standard 61800-9. The Department of Energy (DOE) and others are exploring establishing minimum efficiency levels of IDS power drive systems (PDS). VFD losses considered by Siemens when designing IDS to improve drive system efficiency include:

- *Motor Stator Losses* – Heating (I^2R) losses generated within stator winding proportional to its electrical resistance and square of load current
- *Motor Rotor Losses* – Heating (I^2R) losses generated within rotor squirrel cage proportional to its electrical resistance and square of load current
- *Motor Core Losses* – Iron magnetization losses generated by motor core proportional to induced electromagnetic field strength of stator winding
- *Motor Stray Losses* – High frequency harmonic losses proportional to electromagnetic flux leakage occurring in motor air gap and winding fields
- *Motor & Gearbox Windage & Friction Losses* – Mechanical losses generated by bearing friction, gear meshing and shaft-mounted fans
- *Transformer Losses* – Heating (I^2R) losses and magnetization losses generated by the winding and iron core of VFD input power transformer
- *Converter Losses* – Electronic switching and heating (I^2R) losses generated by the circuit components of VFD output power converter
- *Other auxiliary equipment,* such as but not limited to controls, switchgear, cabling and auxiliary cooling equipment







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 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 which is required so as a result special considerations and components must be addressed.

Another concern arises 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 an 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.

Siemens has the product and application knowledge to properly design the entire system and has the products to solve these kinds of ambient air temperature problems like that of flexible type couplings.

Quick and seamless integration

When delivered to the site, IDS is installed directly onto the equipment, thereby reducing installation and start-up time.

Siemens has a long history in variable speed motor design, engineering and manufacturing, including flexible shaft 2-pole motors. These drive systems are normally assembled via a radially flexible coupling that applies lower side forces per degree of misalignment. This is due to the numerous risks resulting from the use of a radially rigid coupling. Radially stiff couplings apply higher side forces on the driven and driving equipment. They also require additional machine drive train (compressor, couplings, gear boxes, motor) field alignment and maintenance attention.

Conclusion

Siemens IDS creates efficiencies in engineering processes. An optimally designed IDS reduces space around the machine, maximizes energy efficiency, optimizes dynamic performance and increases reliability.

Research shows that IDS delivers

- Up to 98 percent increased availability of an application
- Up to 30 percent savings in engineering time
- Up to 15 percent reduced maintenance costs

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

Business processes for 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.

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