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The Evolution of Integrated Drive Systems

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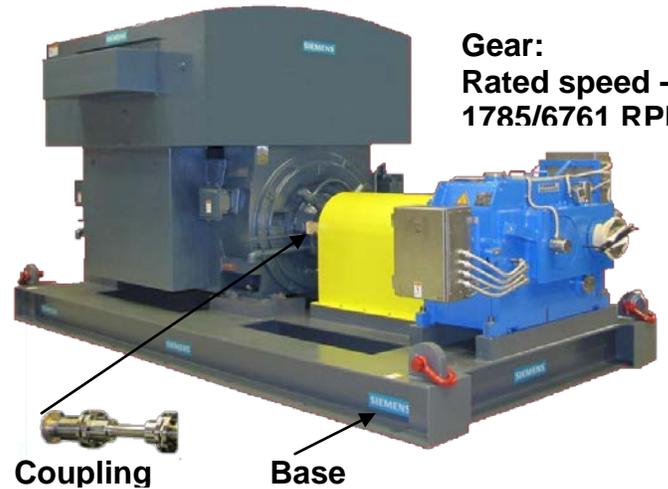
Integrated Drive Systems

Medium Voltage Variable Frequency Drive (VFD)



Motor: 6000HP, 1800RPM, 6kV, TEWAC

**Gear:
Rated speed -
1785/6761 RPM**



Integrated Drive Systems Benefits for EPCs, OEMs, and End Users

Single purchase order for entire drive system

Coordinated delivery times across multiple products

Custom service contracts and extended warranty options

Technologically innovative products and processes from a single source

Matched engineered components

Time to market, development and implementation efficiency

Highly flexible, complete process and customer-oriented solutions

Optimized design efficiencies

Engineered systems built from a comprehensive range of components

Systems responsibility

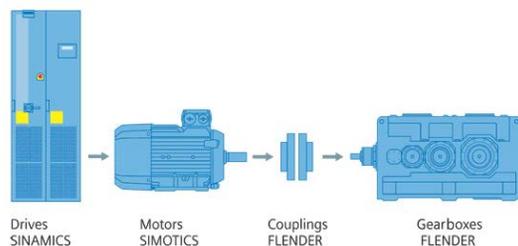
Evolving Concept of Integrated Drive Systems

Siemens introduced the Integrated Drive System as a new concept in 2012 with a complete portfolio of products and experts to provide integrated solutions. Due to the attractive business proposition, the concept continues to make further inroads in the market, specifically in drive train applications with power capacity above 1,000 HP (750 kW). Whether it is a remote mining operation, oil & gas facility, or a large paper mill; when a machine begins to chatter or vibrate, a production shutdown could be imminent. Deciding who to bring in for the service can be challenging since the drive train has components from multiple manufacturers.

Reducing the risk in this business cycle should begin on the day the project was specified by engineering the drive train as a single-vendor solution. Until recently, there were few options for doing this.

Siemens Fills the Gap

Among automation suppliers, Siemens is uniquely positioned to offer a completely integrated drive train as a system purchase. The FLENDER mechanical drives business complements Siemens' industry automation and drives technology to offer a complete integrated drive system.



Siemens Integrated Drive System

For Siemens this has been a natural evolution. The company has a well-established history of providing engineering services to production machinery customers using both standard products and custom-engineered solutions. By working as partners with industrial machine builders in verticals, such as oil & gas, mining and pulp & paper machinery, Siemens has developed an unparalleled understanding of the most complex mechatronic problems.

The internal business processes for project management, engineering analysis, automation topology, and design services developed over decades with industrial machines is directly transferrable to the company's Integrated Drive System offering. All aspects of the drive system, motor, inverter, or gearbox, are customizable where needed to meet the unique application

requirements. All are then manufactured in Siemens' own strategically located production plants. Many plant managers and engineers in a variety of industries that have worked with Siemens on Integrated Drive System projects have realized upfront cost savings. Ongoing benefits are typically further realized with a single source vendor that reduces project management complexity by not having to pass detailed engineering information from EPC to multiple vendors. Normally, the risk of engineering errors is dramatically reduced with a single vendor creating more opportunities to optimize equipment in terms of efficiency and performance.

Traditional Business Practices Disrupted

Working with a single vendor to design, install, and support a drive train offers tremendous potential for improvements in performance and cost across the entire lifecycle of the equipment. Streamlining all aspects of the drive train, will more than likely reduce costs from initial specification, vendor selection, and design, to deployment in the field often provides measurable upfront cost savings. Furthermore, ongoing operational cost savings reduce the total lifecycle costs, since these solutions can be engineered to minimize components and custom engineered to maximize the reliability and efficiency.

To achieve the potential benefits, users must challenge the traditional engineering, design, and purchasing behaviors and business practices. The value potential to an organization can be quantified by simply assessing each phase of a project. The integration and design practices associated with drive trains today require specifications for each and every component. Alternatively, consider a drive system that is delivered fully integrated with inverter, motor, and gearbox requiring only a coupling connection. Providing a single source vendor specification for the entire Integrated Drive System, drive to coupling, is a long overdue positive disruption.

This white paper reviews several recent project achievements completed using the integrated approach in two industries; oil & gas and pulp & paper. In both cases, the value proposition was not immediately apparent. However, project engineers evaluating Siemens Integrated Drive System during the proposal process found the concept to be very attractive, particularly by consolidating the responsibility for the overall drive trains performance to one vendor. When the equipment is engineered and procured as individual standalone components finger pointing often occurs.

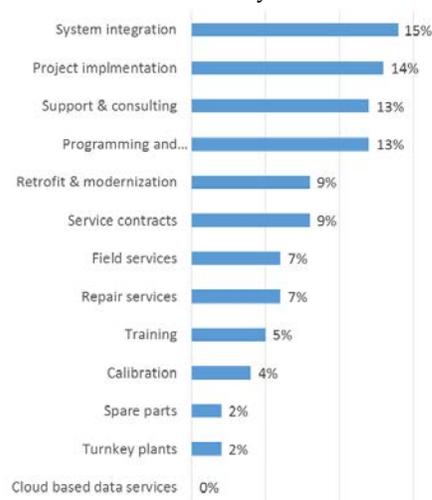
The integrated drive solution eliminates the finger pointing occurring at late stages in a project as to which vendor's equipment is responsible for not meeting performance goals.

The case study in the oil & gas industry discusses the retrofit of a turbo-compressor that has been in operation for many years. In the pulp & paper industry case study, a leading fiber board manufacturer sought to upgrade six-lineup drive systems that were no longer serviceable.

Interestingly, in both case studies, the customer's engineering group did not seek an integrated drive system. Instead, they issued RFQs for the individual components. However, Siemens' Integrated Drive Systems project management team proposed a comprehensive solution that promised (and subsequently delivered) lower deployment, less drive component equipment, and reduced lifecycle service costs.

Disrupting the Status Quo

While this report was being written, it appeared that Siemens is one of the only automaton vendors that have the breadth of product to cover the entire drive train: motor, gear, coupling, and inverter; along with the associated controls. While disrupting the status quo, this concept can be very appealing for plant managers and engineers looking for an integrated system with single-source responsibility across the entire power range.



What type of Services do you plan to Increase the Quality?

(Source: ARC Advisory Group)

Siemens allocates a single point of contact for engineering the order for a custom-engineered, solution. These tasks were previously left to an EPC or the company purchasing the individual components.

In a recent survey conducted by the ARC Advisory Group, manufacturers were asked which types of supplier services they believed required improvements. System integration, project implementation, and support & consulting ranked as the top three. Since Siemens' can address all three service categories simultaneously with Integrated Drive Systems as the company structured its product portfolio and engineering solution to address these industry challenges.

This results in better performance, higher quality, and high reliability solutions for owner-operators. Besides reducing risk, Siemens' integrated approach provides measurable business benefits by reducing upfront design and engineering costs, simplifying purchasing, and reducing warranty costs. Even more significantly, it provides a single point of contact for the entire drive train, eliminating the finger pointing in late stages of a project often prevalent in multivendor solutions. In addition to helping ensure rapid resolution of any problems that should crop up in the field, the approach also provides a higher degree of reliability, as the single vendor is in a better position to engineer a solution that minimizes interface losses, resonances, and wear.

Business Proposition Plays Out for Early Adopters

Our case study in the pulp & paper industry illustrates the path the plant manager and engineers took to ultimately decide on the Integrated Drive System offering, which was not the solution they initially pursued. In the past, drive train solutions were comprised of individual components purchased from multiple vendors as selected by an EPC or system integrator. Industries such as pulp & paper and oil & gas are under tremendous pressure to operate plants with smaller engineering departments while also seeking to maximize productivity. Plant managers are now retiring underperforming capital assets and replacing them with energy efficient, higher performance, and highly reliable solutions. The decision to move toward Integrated Drive Solutions is based on improving these operational metrics in the production plants. More plant managers across industry are looking for implementations that can be managed effectively over their expected lifetime with minimum effort and cost and the integrated drive approach addresses this industry need.

Internal Organization Supports Integrated Drive Systems

Siemens backs its Integrated Drive System offering with standard internal business processes that provide customers with a single point of contact from initial specification to final installation.



**Operations and Engineering Center
Support of Integrated Drive System Project**

The Operations and Engineering Center (OEC), an organization established specifically to support customization and execution of Integrated Drive Systems orders, specializes in Integrated Drive

Systems orders in the oil & gas, pulp & paper, cement, mining, and other industries. Our two case studies in oil & gas and pulp & paper illustrate how customers have worked directly with the Operations and Engineering Center or affiliates.

The Operations and Engineering Center project management group facilitates collaboration across all global Siemens business units and product groups needed to support an Integrated Drive System project. Each project is engineered to deliver a custom solution designed to optimize the operational performance of the equipment. However, by repeatedly using the same organization and standardized processes for Integrated Drive System designs, customers benefit from the experience and knowledge acquired from prior projects.

Lifecycle Improvement

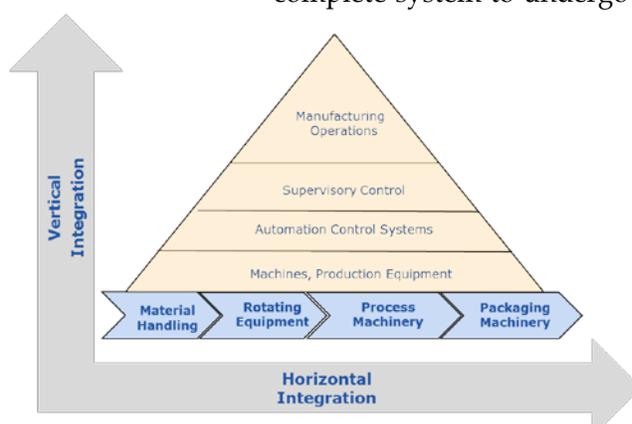
Lifecycle improvements extend from the earliest planning steps, to design and engineering, all the way through to maintenance and updates. This improves productivity, investment security, and reliability. Vertical integration on the application level helps ensure that the drive train fits seamlessly into the entire automation environment – from the field level all the way to the manufacturing execution system. This increases engineering efficiency.

The pulp & paper industry case study also illustrates the value of horizontal and vertical integration. The single point of contact allowed the complete system to undergo factory acceptance testing prior to installation

in the plant; an excellent example of how projected risk can be minimized. Taken as a whole, horizontal, vertical, and lifecycle integration reduce project startup time while increasing the profitability throughout the total life time of the asset.

Project implementations that rely upon multiple vendors for different drive train system components often result in less-than-ideal solutions because a true system engineering approach cannot be applied. In many cases the multi-vendor approach results in “safety factor” stacking by each vendor which ultimately drives up

overall project costs and decreases system efficiency. Performance com-



**Vertical and Horizontal Integration
Increases Potential Profitability**

promises such as increased friction, resonances, and coupling losses can be eliminated by customizing every component for optimal system performance and reliability to help reduce lifecycle costs.

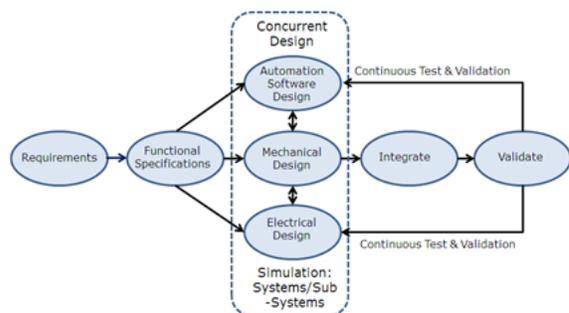
The pulp & paper case study highlights the challenges that plant managers are facing over and over again in their operations. Our studies have shown that the perspective of drive systems will completely change for EPCs, manufacturers, and machine builders in the future. Drive systems will be regarded more than a depreciable asset expected to function with the minimum amount of effort and cost. Manufacturers will perceive drive systems as a direct source of revenue generation rather than the cost of running the business.

Owner-Operators See Business Benefits

Plant and other senior managers are increasingly sensitive to underperforming assets as they reduce profitability. In general, today's owner-operators seek equipment with wider operating ranges and increased reliability. Consequently, designers of drive systems need to consider a larger set of possible solutions. Achieving these goals requires an Integrated

Drive Solution designed using the concurrent design methods widely used in other machinery industries.

Multi-vendor solutions tend to complicate the typical asset life-cycle functions of specification, design, installation, configuration, and project startup. By the time each of the vendors has had a chance to evaluate the functional specifications of each subsystem; alternative design iterations are rarely achievable. Engineering managers understand the high cost of iterative design, resulting in very conservative drive train solutions in the industry.



Concurrent Design Reduces Design Time of Machines

Engineering managers also recognize that the drive train design involves much more than simply selecting subsystem components from a catalog. The ideal is a standard solution that can be custom engineered to optimize every electro-mechanical design. However, there are numerous inefficien-

cies in current drive train development practices that create barriers to optimization across all project phases.

Improved Business and Engineering Efficiencies

Plant managers are confronted every day with older drive systems that can no longer be supported as systems age. Faced with degrading performance and higher service costs, plant managers can make a compelling business case for an integrated drive system approach that requires a single purchase order from the drive to shaft coupling. A single point of responsibility enables optimization in the initial conceptual design phase through the final deployment.



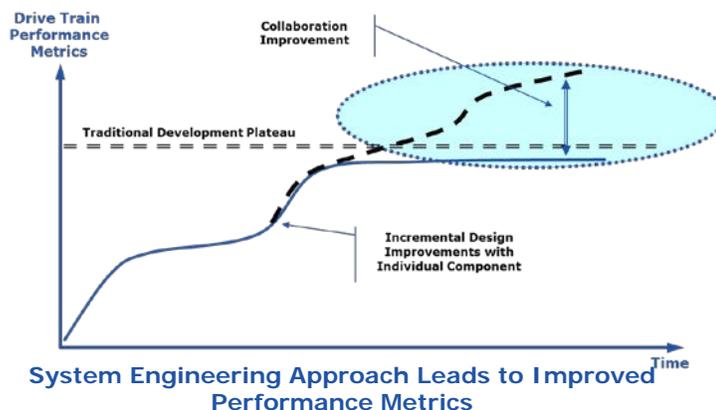
Design is Costly and Time Consuming

Most engineering problems arise from the fact that each engineering discipline uses design tools specific to its respective engineering domain. Mechanical designers use mechanical CAD; drive and motor designers use electronic CAD tools; while automation software developers rely upon development environments specific to automation systems. Without a holistic system engineering approach, it

becomes very difficult to create an optimal overall system design. Combining purchase orders and supplier reductions provide options for customized solutions that better meet the unique application requirements.

Vendor Consolidation Lowers Total Life Cycle Costs

A system engineering approach has been utilized with well-documented success in industries such as aerospace, automotive, and complex systems. These industries have long relied on system engineering and model-based



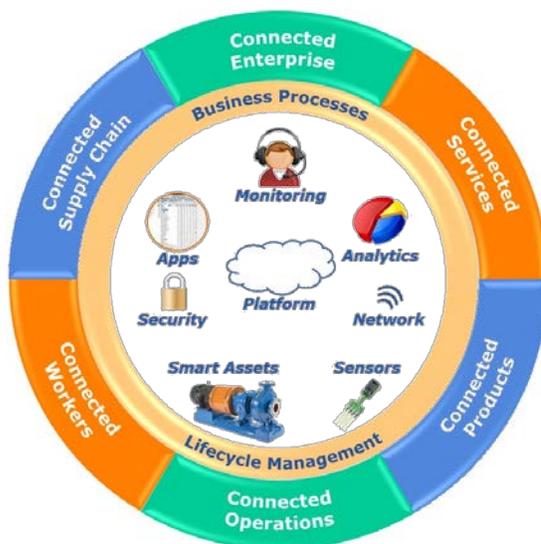
design methods to integrate and validate the development process that takes place between mechatronic design teams.

However, in the past, systems engineering was difficult to apply for drive systems, since the various components typi-

cally came from multiple suppliers. With the single-vendor, Integrated Drive System, these same development methods can be applied to drive systems to optimize asset performance and improve productivity. The premise is that integrated drive systems will exceed traditional performance barriers through collaboration across engineering teams. The expected results are measureable over the total lifecycle of the equipment with lower maintenance costs, improved equipment reliability & availability, and reduced inventory of spare parts. In our two case studies, both companies started seeing the benefits immediately.

IDS Paves the Way Condition Based Maintenance

A typical production plant resembles a distributed set of machinery which is designed to maximize plant output and efficiency, minimize the complexity of servicing these assets and ensure plant operations. But with so many heterogeneous assets in a typical plant, it can be a challenge to implement a cohesive maintenance and service solution. Leading-edge plant operators utilize real time monitoring of assets to implement predictive maintenance solutions to improve equipment reliability and availability to maximize profitability.



ARC's Industrial Internet of Things Model

Drive systems are typically employed in critical applications in industries such as oil & gas, pulp & paper, cement, and mining in which best practices suggest that condition based maintenance approaches work much better than the planned maintenance approaches of the past. Traditional planned maintenance approaches to plant assets typically assume a failure pattern that increases with age or use and require scheduled downtime. Based on ARC research, planned maintenance approaches help to avoid failure of only 18 percent of assets. The other 82 percent of assets display a random failure pattern. For assets like drive systems, a condition

based maintenance approach that employs condition monitoring data to predict failure provides a significant improvement in uptime for availability compared to traditional planned maintenance approaches. Proactive condition based maintenance provides further benefits by combining multiple variables with analytics to predict failure with a higher degree of confidence and fewer false positives.

With Siemens' Integrated Drive Systems, users now have the opportunity to benefit from this approach by leveraging Industrial Internet of Things (IIoT)-connected sensors and predictive analytics. IIoT connects intelligent physical entities (sensors, devices, machines, assets, and products) to each other, to internet services, and to applications. The IIoT architecture builds on current and emerging technologies such as intelligent equipment with an IP address, machine-to-machine (M2M) communications, mobility, cloud computing, analytics, and visualization tools. IIoT with advanced analytics, offers new opportunities to improve the reliability of industrial assets, enabling owner-operators to eliminate unplanned down-time, which many consider to be the ultimate objective for maintenance and operations.

Siemens' drives can provide a connected, sensor-rich environment that works well with the IIoT. Intelligent, connected production assets and new service models are improving performance, reducing operating costs, and increasing reliability across multiple industrial sectors. As an example, Integrated Drive Systems with IIoT-enabled technology can positively impact several areas within the oil & gas value chain. Among some of the most impactful are real-time monitoring, control and optimization of pumps and compressors used for artificial lift, single phase and multiphase pumping, and applications such as chemical injection or CO₂ injection or water flooding.

With Siemens' Integrated Drive Systems enabled by IIoT-connected sensors, Big Data, and analytics, industrial operations can upgrade their asset management strategy with new opportunities for condition-based predictive maintenance solutions.

Pulp & Paper Industry Business Challenges

The global pulp & paper industry is evolving, presenting paper manufacturers with a number of major challenges. Both pulp and paper production is shifting from Northern Europe and North America to large, integrated mills in emerging economies in South America and Asia. Markets in Western Europe, Japan, and North America are stagnating or shrinking across the board. In general, the global market for newsprint is shrinking, while the market for packaging and tissue is growing. As a result, paper mills need to become more flexible.

Overall, paper consumption is directly tied to gross domestic product development.

Company	Country	2015 Sales
International Paper	United States	\$22.3 B
Nippon Paper Group	Japan	\$19.3 B
Stora Enso	Finland	\$12.4 B
UPM-Kymmene	Finland	\$12.0 B
Oji Paper	Japan	\$11.9 B
Westrock	United States	\$11.3 B
Smurfit Kappa Group	Ireland	\$7.3 B
Mondi	United Kingdom	\$5.8 B
Empresas CMPC	Chile	\$4.8 B
Suzano Papel e Celulose	Brazil	\$2.82 B

Top 10 Paper & Paper Products Companies
(Source: Reuters)

This creates demand for new production capacity in emerging markets where regulatory enforcement may be lenient, but appropriate technology and skills are often in short supply. New, increasingly stringent and costly environmental regulations force pulp and paper mills to take adequate measures, which typically impact both production and profitability. While regulatory compliance and enforcement varies from region to region, in many countries compliance is mandatory to sustain operations.

The paper and paperboard industry worldwide annual production has sustained a long term annual growth rate of nearly 2.2 percent and has reached a production level of nearly 330 million metric tons in 2014 (Source: Food and Agricultural Organization of the United Nations, www.fao.org). Emerging markets in Asia have been growing at a much greater rate of around 5.5 percent annually. (Source: ARC Advisory Group Pulp and Paper Industry Trends, Challenges, and Opportunities) Both production and consumption from this region mirrors the growth in Asia's Gross Domestic Product (GDP), which will have a greater share of global growth in GDP over the

next decade. While the majority of growth for the global paper and paperboard industry will come from Asia the mature economies will place greater focus on production efficiencies, environmental, regulatory compliance, and capacity utilization. The pulp & paper industry has a profound impact on the environment, and the impact is more visible than in other process industries, resulting in a relatively more pronounced reaction from the global community. Waste production, air and water pollution, energy consumption, and deforestation are concerns that the industry strives to address.

Energy costs continue to be a major concern and the main strategy for reducing the energy cost is to modernize existing assets. Millions of dollars are being spent to do so. This is especially true in the developed markets where aging assets pose increasing challenges. The benefits derived from close integration of manufacturing and enterprise systems have further encouraged these and other mills to increase investment. Supply chain management is increasingly getting management attention. At the other end of the spectrum, emerging markets are investing billions of dollars to install high capacity, state-of-the-art, automated mills able to operate with increased production volume.

The degree of concern and response varies widely. In the emerging economies – such as China, India, Indonesia, and Brazil – the focus has been on increasing production to match the demand. In the mature economies there has been a deceleration in establishing fresh production capacities due to both the drop in demand and environmental concerns. Specifically, the long term demand for growth in the North American region projected to 2020 is expected to be around 0.3 percent, well below the global average of 2.1 percent (Source: Statista, www.statista.com). Consolidation has further transformed the industry in North America, as major companies have pursued economies of scale and lower costs to stay competitive. Mergers in the past few years have led to a Return On Asset (ROA)-focused manufacturing, turning some large producers into global producers that are in a better position to react to fluctuating demand and compete with lower cost products from Asia. With paper and packaging markets tending to suffer from overcapacity, producers are focusing spending purely on improving manufacturing processes to increase productivity in existing facilities even as capacity increase is occurring in the Asia region (except in Japan).

In the long run, growth rates for capital expenditures in the pulp & paper industry will remain relatively low due to the shrinking demand for news-

print. However, the overarching macro trends of a growing middle class, growth of online shopping, and increasing demand for packaged foods will increase the demand for fine tissue and packaging materials. This will drive investments to convert existing operations or invest in new operations to produce these products. A positive impact on investments is represented by the modernization of old existing paper mills which create new opportunities for automation suppliers. Automation suppliers which have the expertise to help managers optimize new and existing pulp & paper mills by addressing operational challenges and automation migration will be in demand. Full-line global automation suppliers with a process control, drive, and motor competencies are in an advantageous position. In addition to their broad portfolios of instrumentation and control products, systems, and services, global automation suppliers can often deliver complete electrical and drive solutions tailored to the specific needs of the pulp & paper industry, and solutions that satisfy industry demand for improved production reliability and availability, lowering energy consumption, and improved profitability.

Paper Mill Plant Drive Line Case Study

Pulp and paper mills today face the challenge of sustaining profitable operations in the face of rising raw material and labor costs along with high energy consumption. Here, we'll discuss an actual case study in which a US paper mill has experienced reduced upfront costs and anticipates achieving higher productivity and improved equipment availability and performance through a Siemens Integrated Drive Solution.

The Challenge

A leading corrugated paperboard manufacturer located in the US Midwest needed to increase production capacity tonnage across all its mills. Using an internal evaluation process for ranking capital projects they identified replacing the existing six-lineup drives in one mill as a high-priority project. These operate the mill's paper machine from wet end to dry end making them absolutely critical in the production process.

The drive lineup had been installed over 20 years ago through a joint venture between two competing drive and motor companies. The joint venture

has been dissolved and spare parts and service for these drives and motors had become problematic. Furthermore, the reliability of the drives had declined rapidly resulting in unplanned downtime. It takes several hours to rethread the machine, with production costs estimated to be \$15,000 per hour. The escalating cost of downtime made it relatively easy to justify a capital investment for a new, more reliable drive system. In addition, they were speeding the machine up to realize increased production capacity.

Benefits of Integrated Solution

The mill submitted a request for proposal (RFP) to three companies, one of which was Siemens. Siemens' OEC organization immediately assumed a primary role and assigned a proposal engineer as the sole point of contact for the RFP. The proposal manager assembled an engineering team that used a systems engineering approach to analyze the application. The team worked diligently to identify the most cost-effective drive and motor combination from the Siemens portfolio, including custom engineered solutions to the standard product line.

The solution the team recommended was an integrated solution that targeted reducing spare parts (as called for in the RFP) by using common components in the motor and drive. The system incorporates integrated safety and utilized a common DC Bus for the six-lineup drive system. The solution reduced the number of inverter sizes from five to three. While this required selecting drives with a higher power rating that might otherwise be used, the cost difference was negligible and system efficiency remained high. The solution also incorporated the latest innovations in integrated safety, which resulted in a significant reduction in panel wiring.

The proposal was reviewed by both the mill operators and the EPC, which Siemens had involved in all discussions and plant tours to ensure that all parties were on board throughout the design process. Based on Siemens' proposed technical solution, project execution competencies and support resources, the EPC and mill management decided to move forward with the proposal.

Factory Acceptance Testing (FAT) and Startup

The company custom-engineered motors and made-to-order drives were assembled at Siemens factories in the US. This enabled the mill to conduct factory acceptance testing (FAT) locally in the US prior to delivery to the

mill. This made it possible to validate the solution in advance, avoiding the need to perform costly and time-consuming troubleshooting on site.

To streamline the FAT, Siemens simulated the entire production process incorporating both third-party automation and a Siemens process automation solution. This helped the project team compress the time frame of the FAT. Once FAT was completed, the lineup drive systems were disassembled into shipping splits for ease of removal, transport and installation into the new control room. The pallets were loaded into a truck sequentially so they could be unloaded in the correct sequence at the mill to ease installation. Along with the equipment Siemens provided detailed documentation, installation supervision, commissioning and post commissioning start up support.

Quantifiable Savings

The timeline for specification, purchasing, and factory acceptance testing has benefited from the single vendor relationship. However, plant managers anticipate ongoing operational savings due to high availability, reduced maintenance costs, and overall equipment effectiveness.

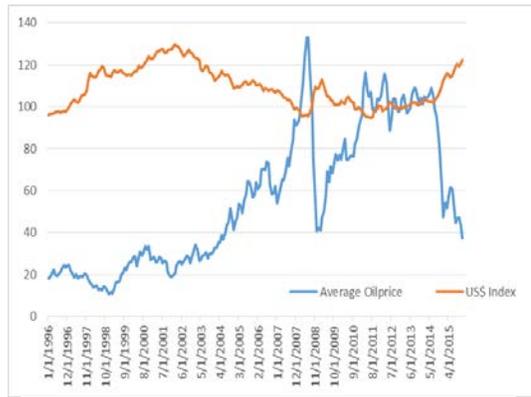
Mill management also anticipates that the increased reliability and availability of the equipment will increase production capacity, allowing them to produce more tonnage of paperboard on the existing paper machine. In an industry where the lowest cost producer per tonnage has the competitive advantage, the ability to optimize existing assets while taking others off line could provide a significant strategic lead.

Oil & Gas Industry Business Challenges

As energy prices continue their steep decline that began in June 2014, the oil & gas industry has been restructuring. The sustained decline in oil prices had the greatest impact on upstream operations both onshore and offshore as the price per barrel of oil has brought many producers to the breakeven or loss containment point in production. The large service providers have started downsizing their workforces. These same companies had previously accumulated both capital equipment and human resources to support an industry that appeared to have unlimited growth, particularly with expan-

sion into the Canadian tar sands and the exploding growth in US shale oil development and production.

The shale oil revolution upset the Organization of the Petroleum Exporting Countries' (OPEC) stranglehold on fossil fuels. In 2014, the US turned the



Oil Price Development
(Source: US EIA)

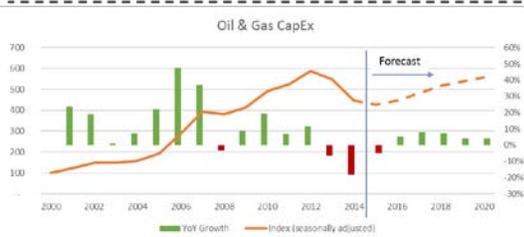
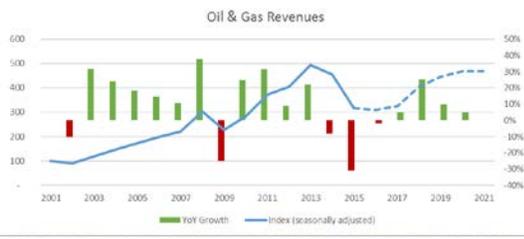
corner and became a net exporter of oil. Rather than throttle back its production to drive up prices, OPEC members chose to maintain production levels in an attempt to drive competitors with higher production costs out of business.

Higher cost (relative to the Middle East) oil producers, such as those operating in US shale, Canada, Brazil, and Russia are suffering. Highly leveraged countries such as Argentina and Venezuela are experiencing even greater difficulties as the lower price per barrel brings in

less revenue, making it more challenging for them to service their debt in dollars. Industry experts have analyzed this market from every possible angle in an attempt to determine when the market will stabilize, but have not been able to determine an accurate prediction.

Upstream Business Adjustments

Capital investments in the oil & gas exploration industry have declined year over year by nearly 20 percent as many companies are shelving assets or holding off investments in high-cost exploration projects such as subsea and offshore drilling. The large owner-operator companies have begun to downsize their headcounts as they adjust the company size for the new oil economy.



Oil & Gas CapEx and Revenues

Despite the intense margin pressure placed on the shale producers in the US, the producers in this region have continued to pump oil to service the low-cost debt amassed over the last ten years. Automation and technological improvements have been adopted during this period enabling the industry to contain costs to mitigate losses. However, the fallout has begun, with bankruptcies beginning to climb since oil prices began to decline. The re-

Downhole Plug Setting Tool

An electromechanical actuator designed to set plugs and packers in an oil well provides an excellent example of advanced technology. The elements of the design critical to product performance include the 1) servo motor laminations and windings, 2) planetary gearing, and 3) ball screw or roller ball screw. The package is a fully integrated assembly that eliminates the use of couplings and is assembled into a sealed housing with pressure compensation.

maintaining US shale producers have managed to maintain production despite the decline in energy prices.

Owner-operators are focused on asset performance and are using asset performance data to drive models to make critical investment decisions. Increasingly, they are leveraging more real-time connections to equipment to enable analysis by remote experts and/or sophisticated analytics software. Companies are deploying

embedded technology inside of machinery to collect and analyze real time data to support condition based maintenance systems. Embedded technology will improve asset performance and lower operational costs. Technical trends include the movement towards increased automation and remote operations management in upstream exploration and production (including offshore and subsea) and real-time management in gas pipelines.

In recent years, technological advancements have been adopted to improve directional and horizontal well-drilling techniques. This has led to the production of vast quantities of hydrocarbons from previously uneconomic, hard-to-reach reservoirs. Precision directional drilling instruments, including high-quality, reliable downhole systems for directional surveying and navigation have improved capabilities to measure shock and vibration at extreme temperatures up to 175°C. Furthermore, today's most advanced drilling systems utilize electromechanical directional steering systems that guide hydraulically powered main drills. While many drilling operations still employ hydraulic steering systems, an increasing number of operators have begun to exploit the benefits of an intelligent electromechanical actuator to enable directional drilling, particularly in extreme environments. The most advanced downhole directional steering systems are integrated electromechanical assemblies that employ custom-engineered brushless servomotors and electronic subassemblies housed in sealed enclosures.

Equipment suppliers that leverage real time production data in upstream operations are offering premium services that can be utilized both remotely and onsite. Aftermarket services and analytical services are differentiating automation equipment suppliers and has now become a key driver in the supplier selection process.

Downstream Operations

While both energy and feedstock costs have dropped for petroleum refiners, the challenge is that oversupply in the market has also reduced prices at the pump. The industry has depended heavily on skilled workers in operations; however, the workforce is aging and this is a concern. Along with an aging workforce, much of the machinery and equipment installed in refining operations as well as a good percentage of the automation assets are well past their useful life expectancy. Downstream operators that have held off investments for decades are now faced with developing strategic capital deployment plans to improve operations to meet the requirements of a downsized workforce and an end market that demands increasingly more versatile products. Many downstream oil & gas industry processes share remarkably similar requirements, illustrating the increasing convergence of automation requirements for all applications across the oil and gas supply chain.

Midstream Natural Gas Pipeline Case Study

This case study is focused on turbine compressor upgrade for a leading pipeline and midstream company based in North America that has been in operation for over a century. During this time the company has amassed a network of pipelines and related infrastructure that connect supply sources to end markets. The company's natural gas operations include about 19,000 miles of transmission pipeline and 300 billion cubic feet of storage capacity in the US and Canada. Due to the tremendous supply increase in natural gas in North America, the company had to improve its infrastructure, including making improvements to its compressor stations to improve delivery to the critical markets.

The Challenge

Some of company's compressor stations were placed in service in the 1950s and '60s. While the gas turbine compressors originally installed have been the workhorse along these pipelines for over 50 years, the technology has changed. Starting these turbines required the use of an auxiliary turbo expander connected to a gearbox, which engages with the larger turbine to achieve the required start-up speed. The turbo expander was then disen-

gaged by a mechanical clutch and coasted to rest. During this entire starting sequence, the compressed natural gas used in the turbo expander could not be re-captured and was vented to the atmosphere. The goal was to replace the natural gas-powered auxiliary starter with a reliable and environmentally friendly alternative, the electric drive and motor solution.

While functional, the current approach to starting the main compressor turbines presented two operational issues:

1. Venting the natural gas in the expander after each start created environmental concerns.
2. The company was reversing the direction of natural gas flow in some pipelines and needed a solution that would allow it to do so without having to seek permits for new equipment.

To solve these issues, the company decided to replace the starting turbine expander with a modern electromechanical drive and motor.

Supplier Selection Process

The company's original specifications for the turbocharger identified a custom-engineered 450 HP motor that could operate at 5,200 RPMs. Initially, the company wanted the original supplier of the turbine compressor to provide the electric motor and Siemens to provide the electric drive. When the system went out for bid, the company was not aware that Siemens could provide a complete solution. However, when Siemens presented an initial proposal with a drive and motor combination that promised to optimize the solution, the company selected Siemens to provide the complete system.

Engineering Design

Using a single vendor for this application proved to work out well for the customer. Siemens assigned a project manager as a single point of contact for the customer for the entire project. This significantly helped to streamline the project timeline versus what would have been when comparing and having to coordinate with two separate manufacturers for the project. Numerous design decisions were able to be quickly resolved with a single vendor in complete control of the drive and motor specifications.

Siemens worked with a local third party to empirically determine the torque requirements throughout the entire speed range. The compressors in the field had two different frame sizes (Frame #3 size and Frame #5 size) which had unique torque and voltage specifications. The Frame #5 size motor required 5,000 volts whereas the Frame #3 size motor required 2,400 volts. However, Siemens was able to provide the necessary torque-speed curve requirements in one interchangeable motor by developing a dual voltage rating.

The designers in Siemens' Norwood, Ohio, Motor Facility used the torque-speed curves as a basis for the motor specifications. Based on the tests, the motor designers specified a 2,133 HP medium voltage motor with a speed range from 0 to 5,600 RPM. Siemens motor designers developed the two frame size motors using the same stator and rotor design, reducing the number of spare parts and lowering both engineering and manufacturing costs.

The medium voltage motors were matched up with a custom-engineered medium voltage drive that was able to handle the unique requirements of the application. The starting sequence consisted of a linear acceleration up to 1,800 RPM. The starter then must hold 1,800 RPM for approximately 4 minutes to purge the system. The motor would then be ramped from 1,800 RPM up to 5,200 RPM. At this point the main turbine is fired and becomes self-sustaining. The starter system is then disengaged and coasts to rest. Due to the wide speed range of this application, bearing design is critical to ensure proper operational life.

A further design challenge was that the substations were not set up to deliver medium voltage power for the drives. While plants typically have medium voltage available, only 480 VAC was available in the customer's substations. Siemens custom designed the front end of the drive to accept a low voltage and still provide medium voltage output. This is a fairly unique requirement in the industry. Being able to accommodate it saved customer from the considerable expense of having to upgrade the switch-gear at each substation.

Up to four turbo compressors were being retrofitted per compressor station. A conventional solution would require a single drive for each medium voltage motor. However, Siemens developed a standardized solution in which a single drive is configured with a sync transfer system. With this technique, motors are started in a staggered sequence and output con-

factors (switchgears) used to switch a single drive from one motor to the next. This is an ideal application for this type of configuration because the motor/drive combination is only required to start the compressor and then unpowered. Once the compressor starts, it is powered by natural gas and the motor turns freely.

Siemens project team tested and validated both drives and motors. Validation tests simulated the motor performance to verify that the matched motor drive combination would perform as specified. The total solution was extremely cost effective as it only requires a single drive regardless of the number of motors that need to be started. During final integration, Siemens engineers assumed responsibility for removing the small gas expander on the existing turbines and replacing this with the custom-engineered motor.

The system engineering approach reduced the required components by using the synchronous system setup and common components for the motor rotor. Overall, the system design achieved customer's original requirements and with the added advantage of increased reliability.

Conclusion

Siemens has formed global, industry-focused organizations over the past four years to better serve its industrial customers. This industry focus concept requires critical understanding of the business issues, manufacturing challenges, technical challenges, and regulatory environment that customers within these industries face.

Integrated Drive Systems (IDS) are a result of this industry concept, offers high value to mining, cement, oil & gas, and other industries. Siemens already has a long and successful history of serving its customers in their specific markets.

Siemens' broad range of integrated field and support services helps its customers maximize the uptime and reliability of their drive components and systems while managing costs. As the service provider who knows Integrated Drive Systems, Siemens leverages its extensive global network. The global network is comprised of engineers, field service and repair professionals, spare parts stocking and distribution capabilities, and user-friendly, online and technical support. This helps its customers minimize plant downtime and optimize production and Return on Investment.

Siemens also helps its customers extend the lifecycle of their plant's equipment. Repair services for legacy products and state-of-the-art systems are offered along with customized service contracts. Other service programs include integrated plant maintenance, condition monitoring, industrial security, energy monitoring, and technical learning services for industrial automation and drives technologies.

Siemens Integrated Drive Systems have been proven to help simplify the vendor selection process, optimize existing design specifications, and ensure that projects are engineered cost-effectively and finished per schedule. Siemens is unique in offering solutions with the full range of couplings, gearboxes, motors, and drives as well as control systems. The company expects the Integrated Drive System offering will markedly improve its customers' ability to respond to market changes and provide them with a clear competitive advantage.

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Acronym Reference: For a complete list of industry acronyms, please refer to www.arcweb.com/research/lists/IndustryTerms/.

API	Application Program Interface	IoT	Internet of Things
CAGR	Compound Annual Growth Rate	OEC	Operations and Engineering Center
DCS	Distributed Control System	PAS	Process Automation System
EAM	Enterprise Asset Management	PLC	Programmable Logic Controller
EPC	Engineering Procurement Construction	PLM	Product Lifecycle Management
FAT	Factory Acceptance Test	RFP	Request For Proposal
IDS	Integrated Drive System	ROA	Return on Assets
IT	Information Technology		

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