MOVING YOUR WORLD

IDEAS IN MOTION CONTROL FROM MOOG INDUSTRIAL

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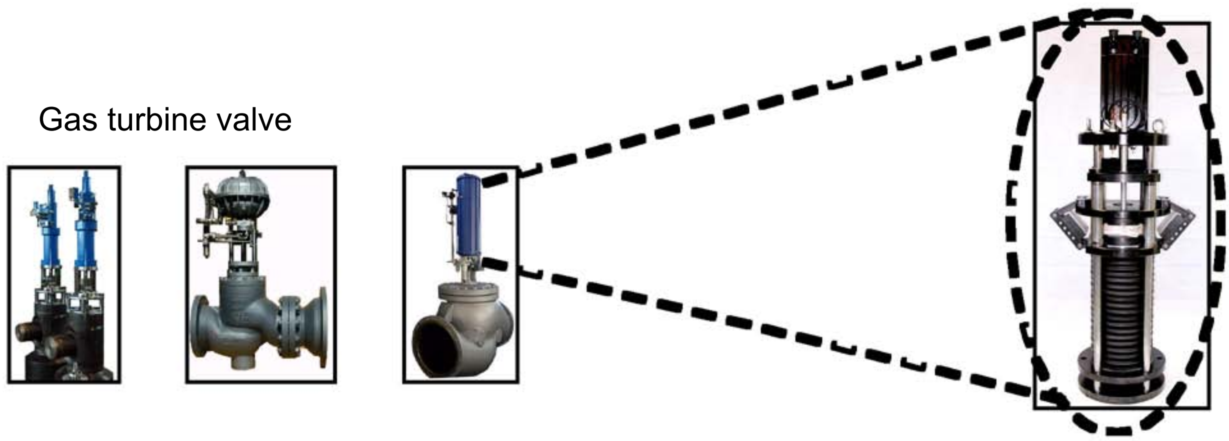
FEATURE ARTICLE

A NEW ELECTRO-MECHANICAL APPROACH TO FAILSAFE ACTUATORS IN GAS TURBINES

By Thomas Czeppel, Manager EM Systems, Moog Germany

Moog has been involved in providing motion control for the Power Generation Industry for over a decade and has been a trusted partner of the leading builders of gas and steam turbines. Over our history Moog has provided over 10,000 servovalves to over 1,000 plants worldwide. Today we design complete control assemblies and unique products in both hydraulic and electric technologies for a variety of turbine control applications. In addition to understanding the design needs of the turbine manufacturers for enhanced safety, up-time, and space saving, we also have vast experience in helping power plants run effectively by facilitating commissioning, operations, maintenance, and troubleshooting motion control systems.



Background

Traditionally most of the process valves on a turbine are hydraulically operated. In this industry, performance measures are closely related to production availability including maintenance hours and startup time. The concept of using an Electro-Mechanically (EM) operated valve is very appealing to the industry for following reasons:

- Elimination of potential fire hazard of high pressure oil leaks
- Removal of plumbing and the decentralized power unit
- Provision of extensive diagnostic capabilities and easy setup due to decentralized intelligence independent from the turbine controller
- Forward - looking system allowing for preventive maintenance concepts
- Overall cost saving, when comparing the total cost of ownership of EM to hydraulic solutions

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Challenge

Main parameters of a gas turbine are controlled through the opening and closing of a valve outlet. In case of an emergency shut-down the valve needs to dynamically close against the gas pressure, otherwise there will be severe damage to the turbine. The safety-relevant closure of the valve is accomplished in this industry through a spring arrangement. In hydraulicly-operated valves the spring is constantly engaged during the operation of the valves. Earlier EM designs mimic this operation and failed due to safety consideration such as a possible jamming of the mechanism or the maximum time allowed to close the valve. Additional problems with the traditional drive train approach were due to the additional spring in the load path being oversized, resulting in larger drives, motors and actuators that were less cost competitive when compared to the existing solutions.

Patented, Innovative Solution

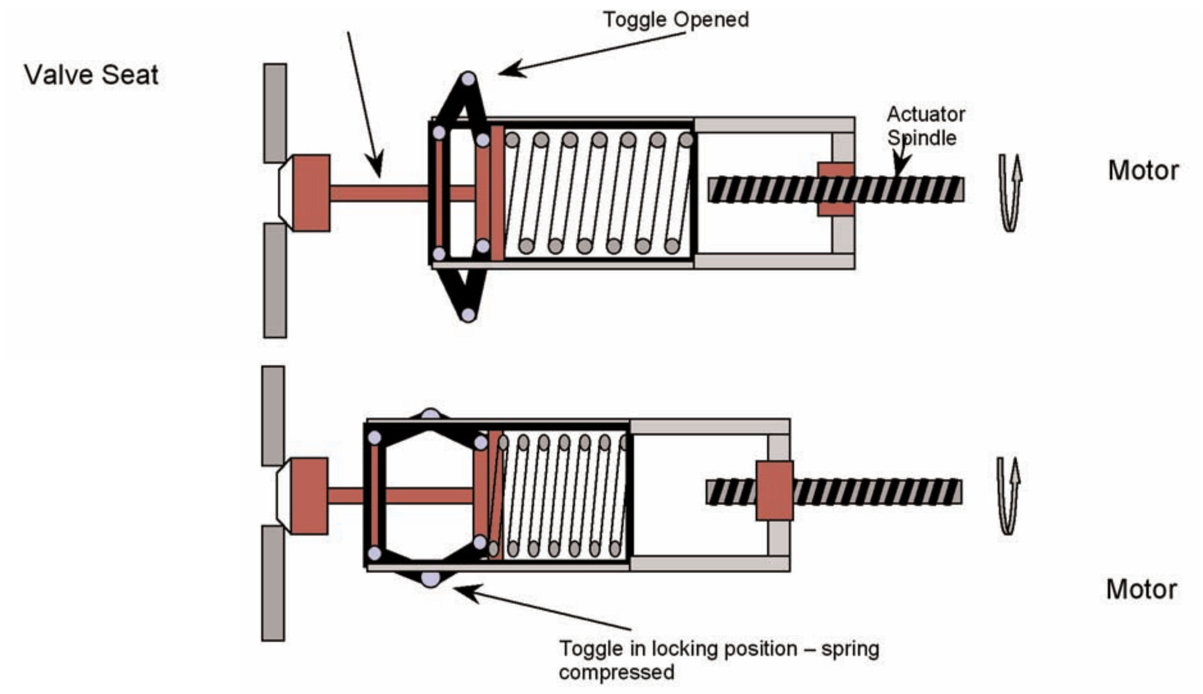
Through collaboration with an industry leader, Moog developed an understanding of the needs and challenges in this application. We received constructive feedback on our designs and perfected our concept through several iterations based on our customer input to arrive at the ultimate design.

Early on in the process, Moog decided to separate the actuation system in two functional parts. The first part was the normal operation of precise position control of the opening and closing of the valve dependent on the target position provided by the turbine controller. The second part was the safety mechanism represented by a spring arrangement that is being compressed during a reference movement and locked in place by the use of a magnetic clutch arrangement

The traditional disadvantage of EM designs were overcome by the following design innovations:

- Servodrive, servomotor and actuator are only sized for the process forces.
- The failsafe is executed by the loss of power to the magnetic clutch. It fulfills the required closure time due to low acceleration mass and does not require back-driving capabilities of the actuation systems.
- Further innovation of the use of a toggle device has minimized the size of the magnetic clutch.

Sketches showing the two functional parts



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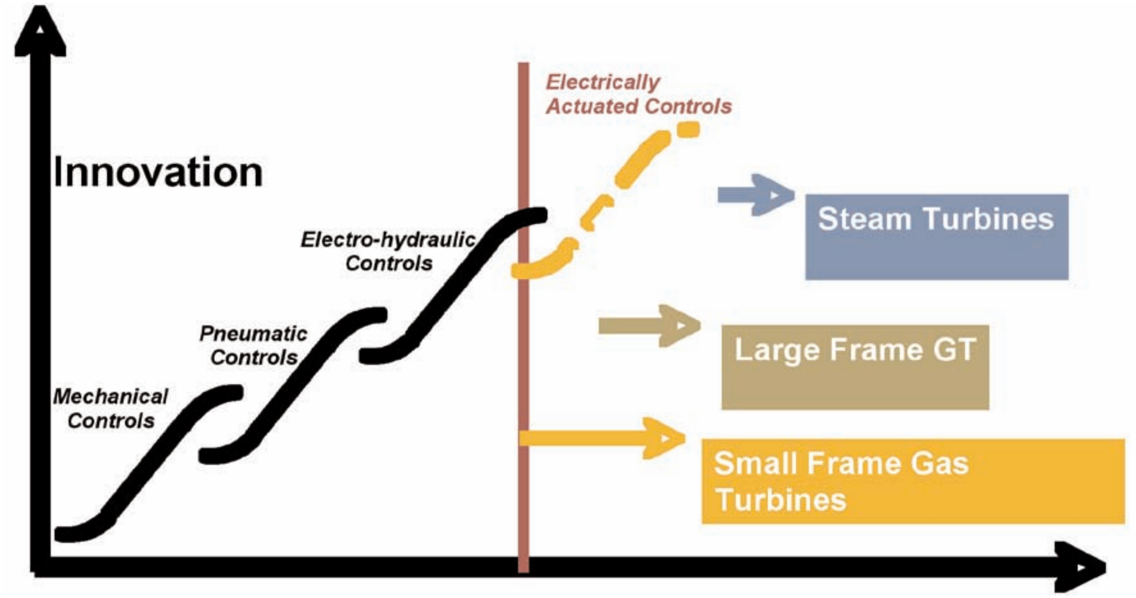


Conclusion

The innovative approach that Moog used in this application resulted in a world-wide patent granted to Moog. This unique failsafe device is currently designed and under testing for small frame gas turbines. The modular design approach will further allow the use in large frame gas turbines and steam turbines. Most importantly, Moog's solution has enabled the industry to overcome a major impediment to the quest for the all electric turbine, thereby continuing our history of helping the industry to overcome its challenges and continually increase performance.

About the Author:
Thomas H. Czeppel is the manager responsible for the development and application of solutions using electro-mechanical technology in Europe. He has worked for Moog for 11 years in engineering and application functions in Germany and the US. He studied Precision Engineering in the University of Esslingen and holds an MBA at the SIMT in Stuttgart.

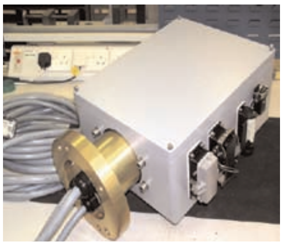
PRODUCT SPOTLIGHT

SLIP RINGS FOR WIND POWER

By Glenn Dorsey, Director, Moog Components Group

Modern wind turbines require delivery of power and signals to and from the rotating blades by a reliable rotary union assembly. Moog Components Group, a sister operating group of the Moog Industrial Group, provides a line of wind power (WP) products that are designed for this application. Slip Rings, utilizing fiber brush sliding contact technology are "no maintenance" rotary devices for transferring electrical power and signals. This fiber brush contact system eliminates the need for common slip ring maintenance procedures such as vacuuming of brush debris, lubrication, regular inspection for wear, and brush replacement.

Moog Components Group also offers fluid rotary unions used for hydraulic power transfer. These fluid rotary unions, with an innovative patented low-leak, long life design, can be combined with slip rings for integrated electrical/hydraulic rotary union solutions. Our fiber optic systems can also be integrated into the rotary union to transmit data and signals on a broad bandwidth fiber optic line. Fiber optic rotary joints provide the rotary connection and multiplexers allow multiple signals to be combined onto a single fiber.



Moog's WP6808 slip ring provides the high power circuit required for electric blade pitch actuation.

A fiber channel to the wind turbine blades cross a rotary interface requiring a fiber optic rotary joint (FORJ), along with multiplexers.

The fluid rotary union (FRU) utilizes a patented low-leak, long life design and can be incorporated as a stand-alone component or integrated with a slip ring.

Appendix: Technical Data

Slip Ring	Signal Circuits	Power Circuits	Sealing
WP6807	6-24 (10 amps each continuous)	All circuits can be paralleled for 240 Amps maximum	IP65
WP6808	18-7-2 (10 amps each continuous)	20, 50, 100, 200, 300 Amps RMS continuous @ 600 Volts	IP65

About the Author:

Glenn Dorsey is a Product Line Manager at Moog Components Group and is responsible for the slip ring and fiber optic rotary components. Glenn has an extensive background in rotary components and motion technology and manages the relationship between customers, markets and product development. Glenn is currently focused on focused on product and business development for medical imaging, wind energy and future combat systems.

ASK THE EXPERT

USING AXIS CONTROL VALVES IN WIND TURBINE APPLICATIONS

By Dipl.-Ing. (FH) Walter Lenz, Teamleader Electronics Engineering EFB Valves

Wind Power is a rapidly developing part of the Power Generation Industry where Moog has specialized for many years due to its unique expertise in motion control. As this article describes, Moog is helping to solve some real-world operational and performance challenges for wind turbine manufacturers and users. Two key challenges our customers are facing today involve trends in the wind turbine market: the size of the machines is increasing rapidly and the need for enhancements in energy efficiency, especially for wind park locations with low or unsteady wind speed expectations. Moog's solution involves a decentralized motion control architecture and the use of one of the most sophisticated valves in existence to provide hydraulic pitch control.

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Background

The trend towards increased turbine size is creating even greater challenges for users trying to maintain and operate systems on a 24/7 basis. Today's installed machines have a nominal power output of 2 or 3 MW and the next generation being developed will have a nominal power of 5MW and more. To add to the complexity of this environment, these turbines are often installed in off-shore wind parks. The trend towards enhancements in energy efficiency is driven by the need to expand wind park locations to improve the return of investment and allow installations in places previously considered less suitable. These challenges are often addressed through blade design, where optimized profiles allow higher output at the same wind speed. This requires a sophisticated pitch control system, as the blades become more sensitive to squalls and storms.

The Moog Solution

In wind turbine application, the requirements are some of the highest in the world regarding the need for reliability of the machines, systems and components. In particular, the design of a pitch control system is key, as a breakdown could lead to critical machine conditions or even – in a worst case scenario – to a destruction of the whole turbine. A hydraulic pitch control system is typically used in this application due to the following advantages:

- Easy and reliable storage of energy for failsafe movements in hydraulic accumulators
- Low risk of actuator break down, due to simple and robust design of hydraulic cylinders
- In a power failure situation, the blade will in all circumstances enter the safe position
- The high power density of the hydraulic axis requires less room than the electric version

Figure 1 shows an example of a hydraulic pitch control system.

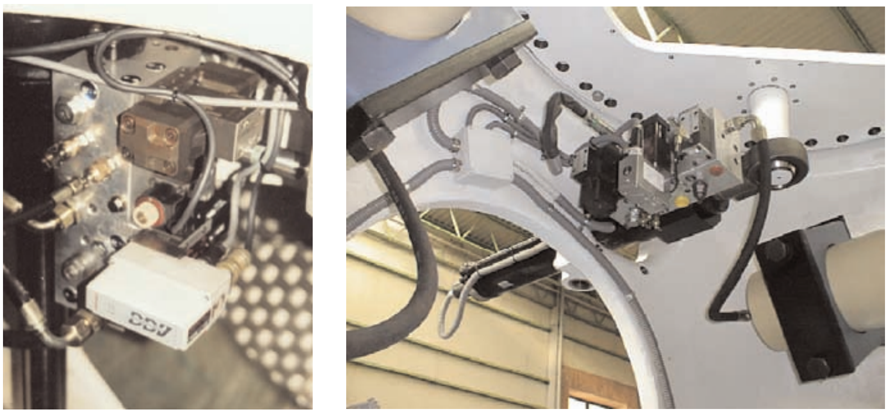

Figure 1

Pitch control systems are located in the hub of the machine, which means that power and signals have to be connected from the (rotating) hub to the nacelle. The connection of hydraulic power can be done easily via a Fluid Rotary union (FRU). To reduce the number of electric signals which have to be connected via slip ring, the preferred solution is a FIELD-bus.

Figure 2 shows the block diagram of an implemented solution. The Moog Servo-Proportional Valve with Integrated Digital Axis Control execute different tasks including:

- Position demand interpolation with built-in trajectory generator
- PID position control
- Axis synchronization (parallel control of three axes)
- Self monitoring of the inner valve control loops and the axis control loops
- Communication with the host (PLC)

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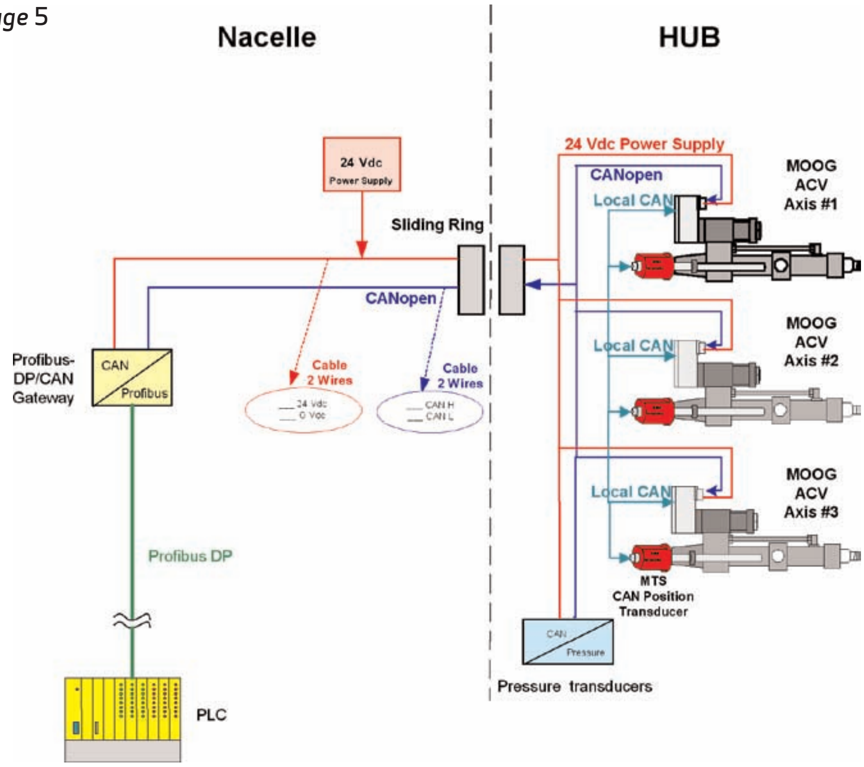


While the position signals from the transducers are supplied in an extra CAN-bus system in order to reduce bus load on the external CAN-bus system, the redundant CAN-bus topology allows a controlled machine shutdown in emergency situations. This is achieved by using a decentralized control architecture. Each valve includes the whole logic to control its own position loop and communicate independently with the PLC system, while it monitors the signals of its adjacent axis. The following are some key safety monitoring functions:

- Loss of position signal (caused by transducer failure or cable break)
- Loss of command signal (caused by bus interruption or PLC breakdown)
- Loss of communication to adjacent axis (caused by bus interruption, cable break or valve malfunction)
- Recognition of emergency situation identified from an adjacent axis

Due to the digital approach and the use of standardized communication protocols and device profiles, the system can easily be supervised remotely, offering huge advantages in this application where access is so problematic. There are several possibilities to achieve a remote control system:

- The CAN network messages are translated into the turbine's network bus protocol with use of a gateway
- Use of wireless technology (Bluetooth or WLAN)

Rationale for Using CAN

Due to the required slip ring for transmission of bus data from the stationary nacelle to the rotating hub, the use of CAN is highly recommended. While Moog's family of Axis Control Valves are available with several FIELD-bus interfaces (e.g. Profibus, EtherCAT), the CAN-bus has proven to be very robust and offer the highest reliability in the field.

Summary

Moog has worked closely with OEM's in the Wind Power industry to develop technology that ensures safety of the turbine, better energy efficiency in previously unsuitable locations, more effective monitoring, and the highest reliability. For the machine builder and user, these benefits translate into lower operating costs, greater safety, opportunities to use this technology in more locations and easier maintenance and troubleshooting. Best of all, our solution now has been proven with thousands of wind turbine systems in the field.

About the Author:
Walter Lenz is a Development Engineer who is responsible for digital valves electronics. He has been with Moog since 1996 working in electronics and software development engineering and is teamleader of the valves electronics development since 2004. He graduated from University of Applied Science Furtwangen in 1995 as degreed engineer in fine mechanics Engineering.

DID YOU KNOW?

NEW GENERATION OF ELECTRO-HYDRAULIC STEAM VALVE ACTUATION SYSTEM FOR TURBINES

By Bernhard Zervas, Systems Engineering Manager

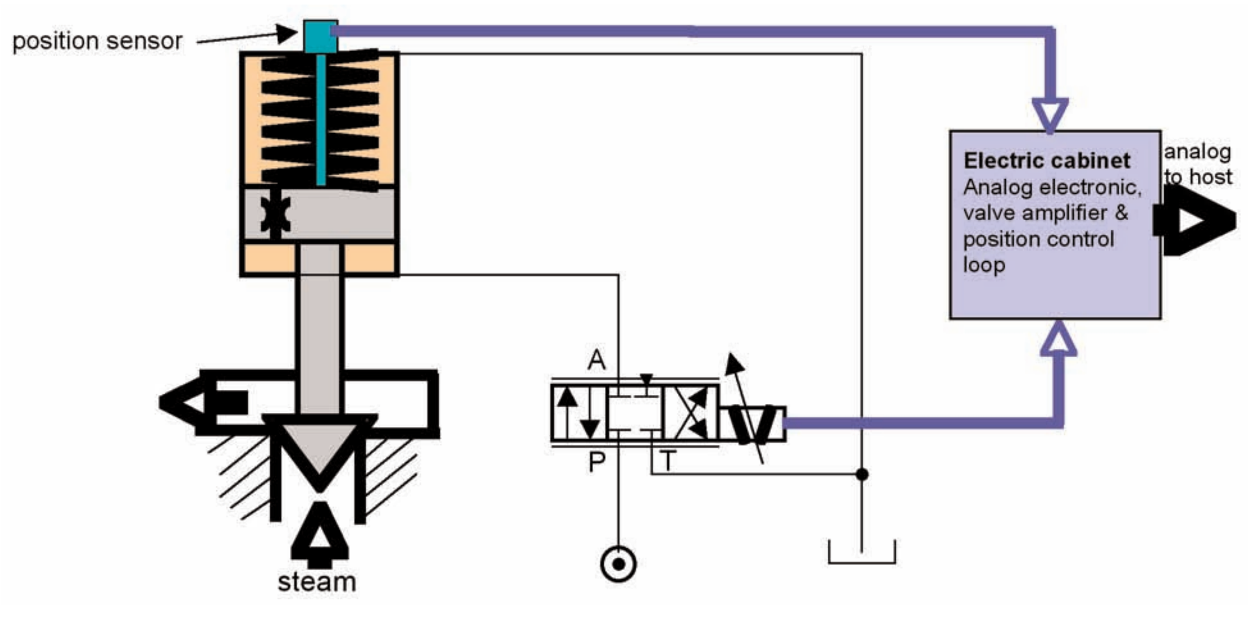
Electrical power stations use large steam turbines, up to 2,000,000 hp (1,500 MW),driving electric generators to produce the electricity. Steam is generated by boiling water using heat from burning fossil fuels, Geothermal heat or Nuclear energy. The turbines used for electric power generation are normally directly coupled to their generators. As the generators must rotate at constant synchronous speeds according to the frequency of the electric power system, the most common speeds are 3,000 r/min for 50 Hz systems, and 3,600 r/min for 60 Hz systems.

The generation of alternating current electricity requires precise speed control. To adapt to the changing demand of electricity, the turbine controller has to control the turbine speed by controlling the steam flow into the turbine. The steam flow is controlled by hydraulically operated steam control valves.

Uncontrolled acceleration of the turbine rotor can lead to an overspeed trip, which causes the steam control valves that control the flow of steam to the turbine to close. If this fails then the turbine may continue accelerating until it breaks apart. As steam turbines are very expensive and a break causes severe damage, any uncontrolled situation has to be avoided. A key safety feature is the design of the hydraulic actuation system of the steam control valves.

Current Steam Valve Actuation Systems

Today's steam valve actuation systems are position-controlled cylinders using proportional valves with external analog electronics. The actuator works against the integrated failsafe spring, which is able to close the steam valve without any external energy, when the control port "A" of the cylinder is connected to tank.



Simplified arrangement of today's steam valve actuation system

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Some disadvantages of the existing system are:

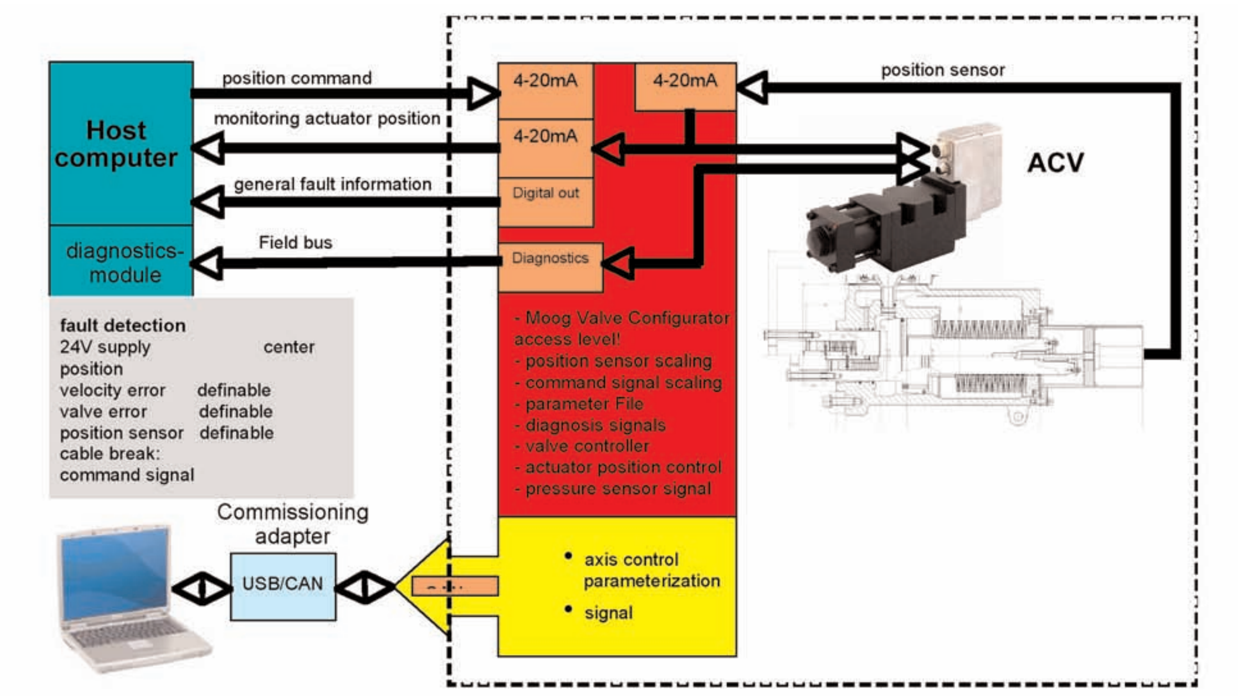
- Commissioning: 6 to 7 potentiometers have to be adjusted at commissioning of the system, which is very time consuming and costly as it requires a skilled person to tune a closed-loop system.
- Replacement: Replacement of a valve or an electronics card is difficult, requiring skilled staff to adjust several potentiometers
- Diagnostics: Troubleshooting is limited to the cylinder position signal

New Generation of Electro-Hydraulic Steam Valve Actuation Solution:

For the new generation of electro-hydraulic steam valve actuation systems, the following specification was given:

- After replacing a valve, no new control loop, valve tuning or signal scaling is needed
- Easy signal scaling after replacement of the actuator position sensor
- Ability to deal with existing analog command signals for turbine upgrades
- Addition of monitoring signals for proactive maintenance and fault identification
- Pressure transducer to provide an additional pressure signal for diagnosis
- Integration of the proven spring failsafe solution

When analyzing the specification, it is clear that digital electronics is required. The ideal solution is a combination of digital control electronics with a proportional valve, the Moog Axis Control Valve (ACV). See picture.



Steam valve actuation system with Axis Control Valve

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DID YOU KNOW? *continued from page 8*

The ACV customized for the steam valve actuation application, provides the following features:

- Easy replacement for existing solutions for turbine upgrades
- Position controller of the actuator integrated in the valve (ACV)
- No new control loop tuning and no signal scaling needed after valve replacement as the stored digital parameters are recalled and easily loaded into the new ACV valve
- Easy signal scaling after replacement of position sensor as the ACV has an integrated semi automatic sensor calibration procedure.
- The ACV can handle existing analog command signals for turbine upgrades
- FIELD-bus interface to monitor signals for proactive maintenance is available
- FIELD-bus interface for remote maintenance is available
- No electric cabinet for control electronics needed
- Integrated pressure transducer in "A" for system diagnostics
- Spool design maintains existing spring failsafe solution

A customized ACV provides all specified features, simplifies the system (no electric cabinet needed), offers comprehensive diagnostics features such as remote maintenance and supports proactive maintenance through an impressive variety of important signals. The new solution is suited for retrofits and turbine upgrades as well as for new turbines.

Analog control and valve electronics can only monitor the deviation between the command signal and the actual position signal. When the deviation exceeds a defined level, the failsafe function is triggered and the actuator has to be stoppedor moved into a defined end position for safety reasons. This is interpreted by the host controller of the machine and the hydraulic actuator system as an unknown defect, which has to be analyzed by the maintenance staff after the emergency stop, thereby resulting in troubleshooting downtime.

By contrast, a modern electro-hydraulic actuation system using a digital Axis Control Valve is able to control the valve itself, in addition to the actuator position. When using a proactive maintenance approach, currently being demanded in more and more factories, it is mandatory to obtain significantly more information about the actual status and wear of the electro-hydraulic actuation system and its components. For example it is highly valuable to monitor, relative to defined tolerances, the static and dynamic behavior of the Servo-Proportional Valve, temperature of the integrated valve/axis electronics, sensor signals, leakage (wear of seals) of the actuator, and process data. The Digital Valve's axis control electronics can make all relevant internal control data available for continuous process monitoring. To be able to transmit continuously the large amount of status information available per axis to a host controller, a FIELD-bus interface is essential for the Axis Control Valve.

With the available data, it is now possible to monitor the wear of the electro-hydraulic actuator, allowing for proactive maintenance at the next planned machine service. The available data provides information about the required activities and enables spare parts to be available for the planned machine service, reducing the down time required. If an Axis Control Valve has to be replaced, no new tuning and adjustments are required as all control parameters are simply copied to the new valve, further reducing down time. Contrast this to the emergency stop scenario with the analog valve. Time is money and digital diagnostics saves both.

About the Author:

Bernhard Zervas is currently the Systems Engineering Manager for Moog's Industrial operations in Germany. He has over 30 years experience in the international hydraulic industry, with a focus on industrial electro-hydraulic closed-loop, electro mechanical and hybrid applications.

HOT WEBSITES: TAKE A LOOK AT THESE WEBSITES

Energy Information Administration

http://www.eia.doe.gov

The Energy Information Administration (EIA), created by the US Congress in 1977, is a statistical agency of the US Department of Energy. Their mission is to provide policy-independent data, forecasts, and analyses to promote sound policy making, efficient markets, and public understanding regarding energy and its interaction with the economy and the environment.

World Wind Energy Association

http://www.wwindea.org

WWEA is an international non-profit association with members in 80 countries. WWEA works for the promotion and worldwide deployment of wind energy technology by providing a platform for the communication of all wind energy actors worldwide, advising and influencing national governments and international organizations and finally by providing international technology transfer.

The European Wind Energy Association

http://www.ewea.org

EWEA actively promotes the utilization of wind power in Europe and worldwide. EWEA members from 40 countries include over 300 companies, associations and research institutions. These members include manufacturers covering 98% of the world wind power market, component suppliers, research institutes, national wind and renewables associations, developers, electricity providers, finance and insurance companies and consultants.

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