MOVING YOUR WORLD
IDEAS IN MOTION CONTROL FROM MOOG INDUSTRIAL
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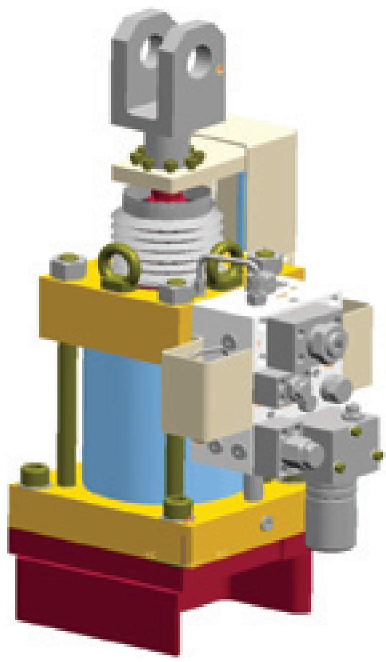
MOOG

UNLOCKING THE KEYS TO LONGER LIFE FOR GAS POWER GENERATION TURBINES

Understanding the small details helps Moog engineers design hydraulic actuators that deliver longer life and less downtime in critical power gen applications

By Ron Gramza, Aftermarket Support Manager

Moog has been a major player in motion control for the Power Generation market for over 20 years and has been responsible for many "firsts" in the industry. The spring of 2004 resulted in all the major OEM's downshifting production and the prospects in this industry looked bleak, but we remained committed to our customers. Even in a downturn, innovative companies know there are opportunities to look at new ways to solve even the most difficult problems. This article discusses an innovative redesign of a specialized hydraulic actuator that responded to the needs of OEMs and end users to increase turbine uptime and reliability. The design innovations incorporated in the new actuator included a rod surface hardness to reduce abrasion, high performance proprietary surface coatings to extend seal life, advanced seal technology to eliminate floating seal binding and leakage, and a stainless steel rod to prevent corrosion. The result is a robust hydraulic actuator that can effectively prolong the life of the turbine and prevent downtime. Moog coupled this high performance hardware with an active support program to help plants easily replace actuators currently in service.



Redesigned Inlet Guide Vane Actuator

Understanding the Reasons for Turbine Downtime

Moog's customer service staff received a few inquiries about power generation actuators that were failing at different gas turbine plant sites. Upon investigation, engineering found that the failure mode was a "mismatch" between the command signal and feedback. Any difference greater than 3% signal variance would trip the engine and an emergency shut-down would commence. An emergency shut-down on a turbine in the power generation world has the following negative impacts:

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1. When a trip occurs the engine shuts down and does not allow the engine to cool in the proper sequence. The engine, while running, generates exhaust temperatures of 538 °C (1,000 °F). If extremely hot parts such as blades are not cooled over time, the life of the engine will be reduced.

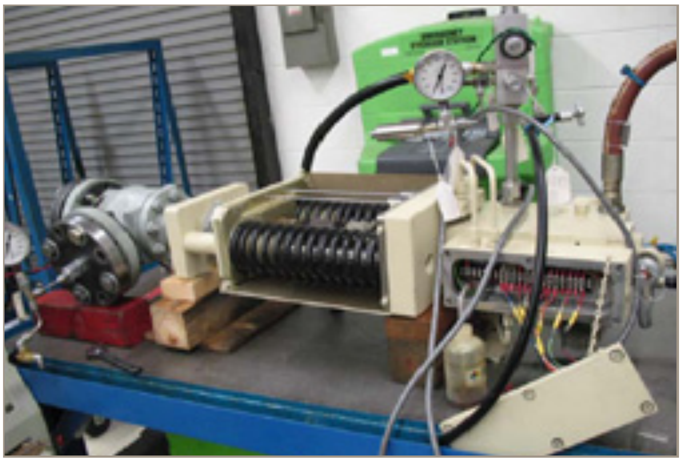
2. More importantly, downtime means that the plant is not improving efficiency and minimizing supply disruptions as well as simply not producing mega watts of power.

The failures started to increase with a particular turbine site which brought this issue to the forefront. An expert team was assembled to investigate the issue and find a solution to the problem. The piece parts were found to be dimensional within tolerance and the entire actuator was checked for misalignment, preload and other setup dimensions. During the investigation, the team discovered scoring between the rod and floating metal seal (used for reducing pressure to rod seal), see Figure 1. This was due to varnish build up and contamination, insufficient edge break on the floating seal and the sealing surface finish could be improved by increasing its hardness. With a nod from the major user, Moog's engineering team embarked on a series of improvements including changing the finishes, edge break and hardness of the material. With improvements in mind, we calculated the failure rate to be approximately 0.5% out of 5600 units shipped. While not statistically significant in terms of failure rate, for these customers it was a very serious source of downtime.

Figure 1. Problem point: scoring between the rod and floating metal seal.

In 2007, Moog began the process of redesigning our hydraulic actuator and began to identify some of the challenges that would need to be addressed. One of our major end users helped in pulling some of the following data together:

- The actuators in use may see about a million micro cycles through the course of a year. In layman's terms, the actuator will travel close to 50 km (31 mi) with a stroke of no more than 31.75 mm (1.25 in).



Gas Valve Actuator enduring life-cycle testing

- The actuators were controlled with lube oil. Lube oil leads to a higher exposure to contaminants from bearing wear and heat exposure of oil in bearings located elsewhere in the system. Over time the lube oil breaks down as a result of heat and pressure, causing varnish to form, which of course is detrimental to the operation of the servo actuator. See Figure 2. Our new solution had to address both of these challenges and offer the same high dynamic performance and form factor as in the past.

Figure 2. Problem point: As lube oil breaks down varnish forms which is detrimental to servo actuator operation.

The Moog Solution

Improving the reliability of Gas Valve and Inlet Guide Vane (IGV) Servo Actuators, while meeting demanding operating conditions, required a new approach to actuator design. Moog's extensive internal R&D and engineering experience in robust product design gained from work in demanding actuation applications, which include fatigue test systems and flight controls for military and civil aircraft was useful in addressing these severe operating conditions.

Moog re-engineered our Gas Valve and IGV Servo Actuators to provide extended service life between maintenance cycles. We adopted field-proven material and coating enhancements that have proven effective in on other demanding high cycle applications. Moog then applied millions of test cycles using actual field motion profiles to validate our design.

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While the new seal package and actuator were in life cycle testing, our sales department solicited a number of sites that were experiencing the same failure modes. A large site in Texas indicated they would be willing to beta test the new design for a year. We signed an agreement and went forward with the plan.

After one year of in-service test, the Gas Valve Actuator was returned to Moog for test and inspection. The engineering team from the user site was invited for the inspection. The innovative design was validated when we did not find any degradation to the rod or seal package and all components functioned as expected. See figure 3. We also found that small varnish droplets from the lube oil started to adhere to the internal components of the actuator which suggested that the new design will withstand the affects of varnishing contamination. We had successfully met the challenges posed and created a new design that will truly extend the life of the gas turbine.

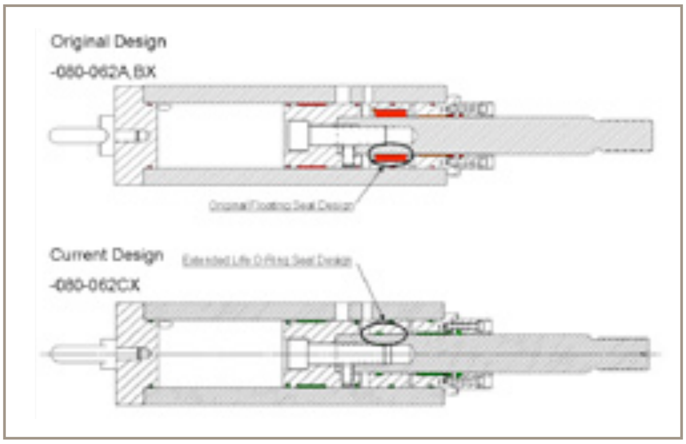
Figure 3. Comparing old design (right) with new design (left) after one year of operation validates no degradation.

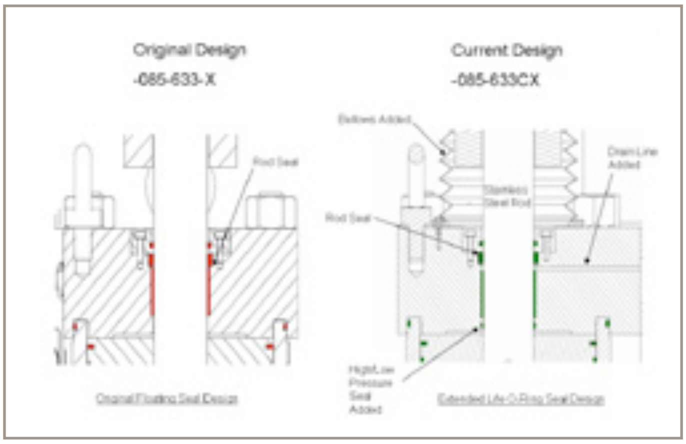
Features and Benefits of Moog's Gas Turbine Servoactuator

- Increased rod surface hardness leads to reduce abrasion for longer life and minimal leakage
- High performance surface coating on rods improves surface finish and extends seal life
- Advanced seal technology to reduce system pressure behind rod seal
- Eliminated the floating metal seal design that was susceptible to binding and scoring due to varnish and particulate contamination
- Stainless steel rod to prevent corrosion

Next Steps

The new enhanced servo actuator design is now available in the marketplace to seamlessly replace Gas Valve and IGV Actuators currently in service. Moog has developed an innovative new service program that offers exchange inventory that is available for planned outages or emergencies in key locations around the world. Special actuators for easy and quick turnaround are also stocked at Moog and at Moog Authorized Distributors in the Americas. Moog has successfully taken the actuation know-how our engineers have gained through working on some of the world's most demanding applications to solve real world problems in the field. If you have a motion control challenge to solve, let us know.





Author

Ron Gramza has been with Moog for 14 years and in the Industrial Group, Americas in various positions including Sales Engineer, Repair Administration Supervisor and now Aftermarket Support Manager. Ron started at Moog as a test technician in Space Products in 1996. Ron studied Electrical Engineering at State University of New York at Buffalo.

MORE CONTROL, LESS COSTS: INSIDE THE MOOG SPEED CONTROLLED PUMP SYSTEM

How the Moog Speed Controlled Pump System reduces energy usage by up to 30%—while also lowering the total cost of ownership

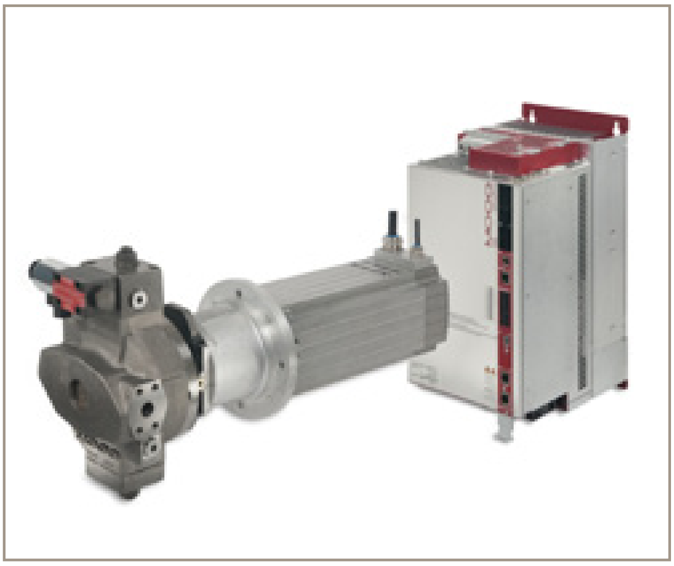
By Achim Helbig, Innovation Manager and Robert Luong, Product Marketing Manager

Working with a variety of customers in many demanding industries gives Moog's engineers a unique opportunity to learn about issues that are concerning today's machine builders. The two we hear most often is the need for energy efficiency and how to lower total cost of ownership. These were the key drivers behind the latest innovative development Moog has recently launched into the marketplace - the Speed Controlled Pump System (Moog SCP System). This article discusses our experience with testing this system on a customer's hydraulic machine and the impressive energy savings experienced in the application. This test represented a good example of an application for hydraulic control where the need for energy efficiency is growing globally and the cost pressures are high.

Application Needs

The conventional hydraulic system for an industrial machine consists of a variable displacement pump and an induction motor which is directly connected to the power grid. In this typical system, the motor runs at a constant speed, normally at 1,500 to 1,800 rpm, and uses the internal mechanism to change the output flow of the pump. In this system there are substantial energy losses in the induction motor and in the adjustment mechanism of the pump, particularly when the system is working under partial load or working in standby mode.

For industrial machine builders, increasing energy prices and the need for environmental awareness are strong drivers prompting end users to request machines that are high performance but also with lower energy consumption, reduced total cost of ownership and improved environmental conditions such as sound emission levels.



Moog SCP System

Energy Savings with the Moog Speed Controlled Pump System

Moog's SCP system consists of integrated building block products including a dual displacement Radial Piston Pump (RKP), the Maximum Dynamic Brushless Servo Motor and the Modular Multi-Axis Programmable Motion Control Servo Drive (MSD). The key functionality it offers users is the ability for them to change the speed of the motor and pump and enable control of fluid flow.

Working with our customer we found the system was able to optimize energy efficiency on their machines. The energy efficiency of the machine with the SCP system was higher, especially when the machine works under partial load. With a medium load, the efficiency is 20 to 30% higher compared with a traditional system. When a machine is running without load, or in a standby mode, energy consumption is even up to 90% less. Under full load conditions, the performance compared to the variable displacement system is nearly identical.

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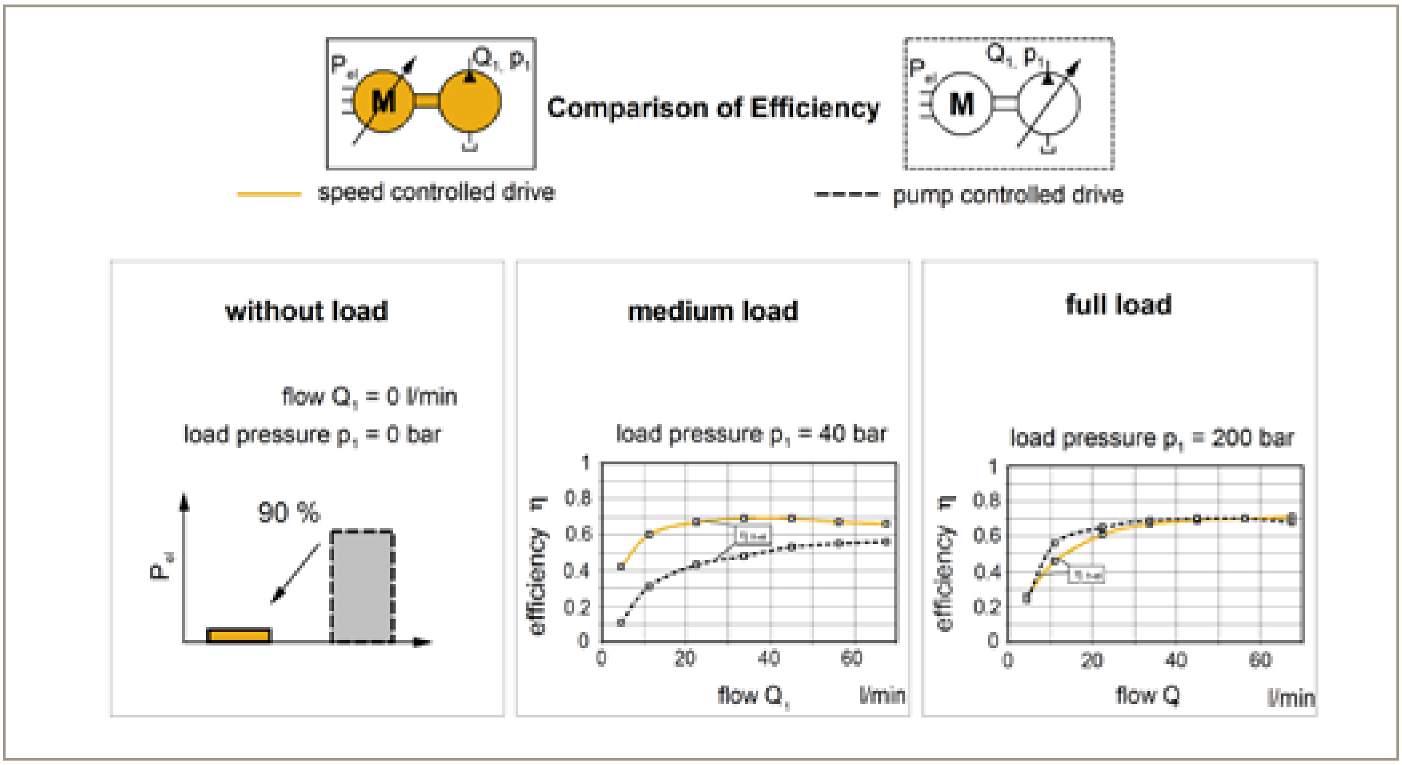

Efficiency Diagrams

A Flexible System with Many Innovations

While the concept behind the system is not new, Moog was able to innovate on the technology for a few key reasons. The primary building blocks are all designed and manufactured by Moog, allowing our engineers to optimize their performance in an integrated system. For example, the MSD Servo Drive provides control algorithms that work seamlessly with our high-efficiency, low-leakage pump technology. It provides pressure and flow control functionality and provides the required torque and speed settings depending on pressure and flow demand values.

Another important innovation in the system is the dual displacement pump design, which allows the pump to operate between two displacements. This functionality is especially important if the application has a load-holding phase where the machine needs low flow, but high pressure. With a dual displacement pump design, it's possible to switch to the lower displacement, which requires a reduced torque. And as a result, the motor size required for the system can be reduced and this leads to energy savings due to the more efficient operation of the motor.

Dual Displacement Design

Comparison to Conventional Technology

In addition to energy savings, the SCP system offers the advantages of a more compact design and easier system integration. The package is more compact as the size of a synchronous motor is much smaller than the corresponding size of the induction motor. Integration is more straightforward when compared to traditional systems where the fieldbus communication is interfaced through the pump control because it is linked to the automation

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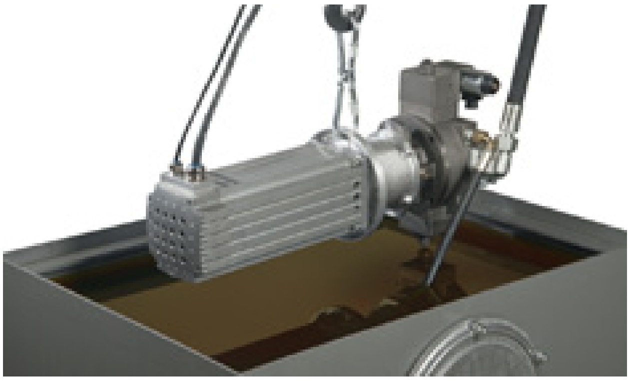
system. In the SCP system the fieldbus is through the servo drive electronics, similar to the configuration in an electromechanical axis, making it easier to integrate.

The Moog SCP also can be designed with a submerged installation of the motor and pump inside of the tank, taking advantage of the heat dissipating fluid in tank and further reducing the size required for the motor and requiring no extra motor cooling arrangements. As a submerged installation requires a smaller footprint, the machine designer is able to optimize the machine size. In addition, the level of sound emission of a submerged version can be significantly reduced, no suction and leakage lines are required and external leakage from pump is no longer an issue.



Submerged SCP Installation

Conclusion

This Moog Speed Controlled pump solution can be considered for a range of applications using variable displacement pumps today. Some obvious candidates that can benefit from the energy efficiency advantages include die casting, injection molding and wrapping or bending machines. Whenever the focus of the application is on energy savings, compact design or easier integration, this new technology provides an attractive solution.

When comparing the cost of this new system with a conventional system that uses a variable displacement pump and a constant speed induction motor, it is important to consider the total cost of ownership. Even if the initial cost will be higher, our calculations and tests on customer machines show that the total cost of ownership is significantly lower. Typically after two years, the sizable energy savings will more than make up for the higher initial investment.

If you think the new Moog Speed Controlled Pump System offers an interesting new option for your machine, contact your local Moog office to learn more. We always welcome the feedback of our customers and other industry experts to help advance motion control technology in industrial machines.

Authors

Achim Helbig has been with Moog since 2004 in the position of Senior Applications Engineer, Team Manager Hydraulic Systems and Innovation Projects Manager. Prior joining Moog he has worked in the Dresden University where he completed his PhD.

Robert Luong is Product Marketing Manager for Moog with more than 15 years of experience. He specializes in the areas of competitive intelligence and product marketing, with an emphasis on price management and product positioning. His technical background includes technical sales, applications and systems engineering consultancies.

Contributors

Peter Lillqvist joined Moog Finland as Application Engineer in 1999 and worked as a System Sales Engineer since 2001. He worked as the Area Manager Finland from 2005 to 2008 when he moved to Moog in Germany as Senior Applications Engineer. Peter holds a MSc degree in Automation Engineering from the University of Tampere.

Werner Händle has worked for Moog since 2001 as a Senior Systems Engineer. He has over 20 years of experience in hydraulics and he studied Mechanical Engineering and Controls.

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