MOVING YOUR WORLD
IDEAS IN MOTION CONTROL FROM MOOG INDUSTRIAL
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FEATURE

HIGH POWER, HIGH SPEED, ALL ELECTRIC INJECTION MOLDING SYSTEM FROM MOOG OFFERS NEW OPTIONS FOR MACHINE BUILDERS

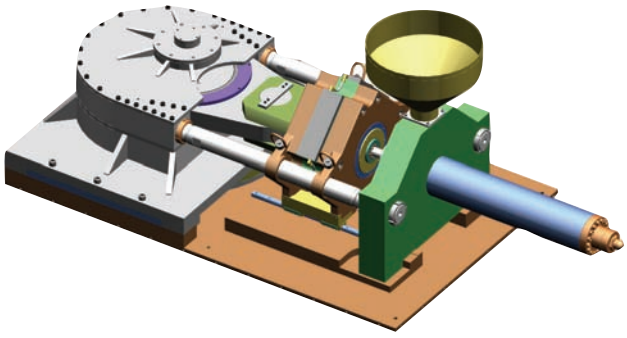
By Burkhard Erne, Business Manager, Moog ProControl,
Choonman Kim, Plastics Market Manager, Asia Pacific, and
Sunil Murthy, Marketing Manager, Americas

Today's injection molding machine manufacturers are experiencing rising resin costs driven by high petroleum prices, increasing demand for thin walled parts from the electronics and automotive markets and growing environmental regulations mandating clean and quiet factory floors.

These market drivers combined with increasing competition are requiring Injection Molding Machine OEMs around the world to look for avenues to add value and to differentiate their machines from their rivals.

These trends are prompting Injection Molding Machine OEMs increasingly to favor more electrical motion control solutions in their new machines. Electric motion control solutions offer benefits such as higher productivity and increased precision together with the advantage of oil free operations and lower noise levels than the existing hydraulic designs.

Moog has been a leader in providing high performance motion control solutions to plastics machines OEMs for over 30 years. As experts in hydraulic, electric, and hybrid technologies, Moog is uniquely able to recommend the best solutions for machine builders based on their specific needs. In the last issue, we featured our newest hydraulic solutions and this article focuses on a specific electric motion control solution developed by Moog that improves precision and energy consumption of injection molding machines with the direct benefits of reduced resin usage, lower energy costs and improved part quality



Moog High Power, High Speed,
All Electric Injection Molding System

Moog All Electric Injection Molding System:

In 2005, Moog acquired Switzerland-based ProControl, a company with great expertise in motion control solutions for injection molding machines. ProControl and Moog have had a very successful partnership since 1991, marrying the building block products from Moog and the application expertise of ProControl. Moog ProControl has vast experience in the marketplace to help address the challenges faced by the injection molding OEMs as they create new all electric machines.

This Moog ProControl collaboration has resulted in a truly innovative approach to precise control of the injection axis: the new High Power, High Speed All Electric Injection System. This unique alternative uses a non-linear actuator and direct drive servomotor to drive the injection screw vs. traditional ball screw and timing belt arrangements. The resulting solution offers impressive results in higher productivity, better efficiency, and lower maintenance, while being scalable and versatile in adapting to many machine sizes and different applications.

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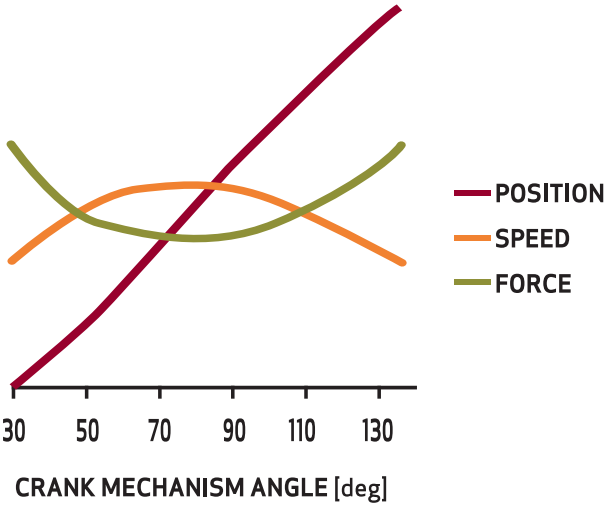
Various OEMs have expressed interest in the All Electric Injection System and Moog has collaborated with an industry leader in Asia to develop two machine sizes (60 ton and 110 ton) initially with an All Electric Injection System. This customer has sold the two machines to an end user in a mobile phone application and placed additional orders with Moog. The customer plans to extend his range of machine sizes based on the All Electric Injection System concept.



How does it work?

The High Power High Speed Injection System consists of an injection and a plasticizing unit. On the injection axis, a High Torque Direct Drive Servomotor works together with a planetary gearbox and a nonlinear actuator to provide the translational movement of the injection axis. Another High Torque Direct Drive Servomotor rotates the plasticizing screw. Closed-loop injection speed is based on the feedback of the angle of the nonlinear actuator and its angular velocity. A load cell is used to control force in a closed-loop.

Benefits of the Moog All Electric Injection Molding System

Tailored for thin wall applications

Machines for molding thin-walled parts require higher injection speeds, response, and injection pressures to fill complex molds in a mere fraction of a second. The Moog All Electric Injection System uses a non-linear actuator and High Torque, Direct Drive Servomotor to drive the injection screw. This reduces overall inertia and maximizes energy efficiency, making more power and higher speed available in a shorter time compared with the ball screw/timing belt arrangements widely used on all-electric injection molding machines.

Higher Productivity

Moog's All Electric Injection Molding System is designed to improve productivity. By reducing the inertia of key elements in the system, injection rates have been significantly improved, which leads to faster fill times.

Better Efficiency - more shots for the same energy

A high power density Direct Drive Servomotor is used to drive the plasticizing screw, providing the best energy efficiency.

Low Maintenance - a key to higher up time

The Moog All Electric Injection System is a truly robust solution for the molding of thin walled parts on small-to-medium-sized high performance machines. Its non-linear actuator is designed to be low-friction and durable for reduced maintenance burden and total cost of ownership. The MTBM (mean time between maintenance) is 30,000 hours.

Higher Precision leading to lower material costs

The low-friction design of the Moog All Electric Injection System, which keeps system heat lower, combined with Moog's patented method for superior pressure control during the transfer between injection and holding phases, allows the Injection System to maintain tighter tolerances on shot weight to reduce raw material costs.

Versatility- Easy adaptation for different applications

The Moog All Electric Injection System also can be used to produce thick walled parts such as lenses. The non-linear

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DID YOU KNOW

ADAPTING SERVODRIVE PERFORMANCE FOR BLOW MOLDING APPPLICATIONS

By Franco Talpone, Training and Applications Engineer and Ugo Di Lalla, Systems Engineering Manager

Some of the unique requirements of applying servodrives for Parison and Blow Pin applications in blow moulding machines include the need for protection against incorrect commands or wiring failures, easy set tuning and troubleshooting for users, and an interface for analogue feedback to help retrofit old machines.

Moog was able to integrate its DS2000 Servodrive with its Modular Parison Controller by adapting the software to allow digital position loop closure and the implementation of special functions useful on blow moulding machines. There were no hardware changes to the standard DS2000 Servodrive. This solution is called the PDS2000 and it can be used for any application requiring analogue position reference and/or analogue feedback. It is optimised for Moog's Fastact G, Fastact T and Fastact Y Servomotors.

Description of the PDS2000 Servodrive Solution

Using two parameters (CW and CCW Override SW) it is possible to program the servodrive to add or subtract an extra stroke to the measured one in order to get specific application functions:
Blow Pin Application: The effective stroke is set wider that the measured one so the actuator can push against a mechanical limit to cut the bottle top (Positive Value).
Parison Control Application: The effective stroke is set smaller than the measured one so the actuator cannot hit any mechanical limit, thereby avoiding damage to the machine head and/or parison actuator (Negative Value).

Key Features

- 4ms Serial Link refresh time; position loop closure via serial link in 8 ms
- Speed and position gains fully programmable
- Auto run of homing sequence at every drive power on; repeatable upon command after a drive reset
- Consistency check/limitation of reference command against the detected stroke
- Feedback transducer open circuit monitor
- The position feedback can be either the motor resolver or an absolute analogue transducer (usually a potentiometer), applied on the "**AN FEED**" differential input .
- The position set point can be analogue (-10 to +10 V), applied on the "**P REF**" differential input, or digital through Serial Link Position Command on RS 485/422 interface.
- Analogue position command programmable within ± 10 Volt range
- Analogue feedback output range within ± 15 Volt
- Feedback transducer power supply got from J2B connector (+15 V dc,100 mA max)
- Incremental feedback achieved through the motor resolver
- 10 bit resolution of analogue inputs:
  - > for ± 10 Volt, the LSB weight is 20 mV
  - > for ± 15 Volt, the LSB weight is 30 mV
- 12 bit resolution for resolver pole pair:
  - > for two poles resolvers, the LSB weight is 0.09°, 5 sterad.

About the Authors:

Franco Talpone is responsible for training and new applications for Moog in Italy. He has been working at the Casella location since 1994 and prior to this he taught in Public Schools and University. He has a Ph.D in Physics.

Ugo Di Lalla is the Systems Engineering Manager for Moog in Italy - Malnate site. He joined Moog in 1990 and he has been working on aerospace and industrial control systems since 1978. He has a University degree in Mechanical Engineering.

characteristic of its actuation system closely matches the molding process for thick wall parts where only force or speed is required at one time. This allows longer hold-on time at higher pressure, with minimal power consumption. In contrast, the linear actuation typical of most all-electric machines requires hold-on pressure to be reduced very quickly to avoid overloading the injection axis servomotor and drive.

Scalability- from 50 tons to 4,000 tons

The actuator system of the All Electric Injection System may be scaled up and down easily for various speed, torque, and power requirements for small-and-medium sized machines. With some additional modifications to the gearbox the All Electric System can be scaled up to 4,000 tons.

Demonstration Unit Data

The 200-250 ton demonstration unit of this solution1 has been tested for over one year and has produced injection speed of 600 mm/s, acceleration time of 35 ms, injection power of 300 kW, and 80% holding pressure (unlimited time).

Specifications of All Electric Injection demonstration unit

Screw Size	mm	50	56
Injection Stroke	mm	200	
Injection Rate	Cm3/s	1178	1478
Maximum Injection Speed	mm/s	600	
Acceleration Time	ms	35	
Injection Power	kW	300	
Maximum Injection Pressure	MPa	250	200
Maximum Holding Pressure*	MPa	200	160
Screw Speed	RPM	320	
Clamping Force	ton	200-250	

* Unlimited holding time

Conclusion

The All Electric Injection System is one example of how Moog applies its motion control expertise to help companies achieve high performance and differentiate their machines from others in the marketplace. Our ability to collaborate with our customers and deliver solutions tailored around their unique needs, is illustrated here by effectively embedding application-specific knowledge in a high performance combination of motion control software, drives, motors and mechanical actuation. Moog's long time leadership in motion control for plastics machines now includes many unique electric, hydraulic, and hybrid solutions that are offering new options for machine builders contemplating future designs.

About the Authors:

Burkhard Erne is the Business Manager for Moog ProControl,the Switzerland-based company focusing on Motion Control Solutions for the plastics industry. He has joined the ProControl team in 1984. He has a Bachelors Degree in Mechanical Engineering.

Choonman Kim, the Plastics Market Manager in the Asia-Pacific region based in Korea, is responsible for the plastics engineering team in this region and for the development and support of solutions for specific customer requirements in the plastics market. He has worked at Moog for 18 years, mostly in the plastics machines industry. He studies Electronics Engineering at University.

Sunil Murthy is the Marketing Manager for Americas. His previous experiences have been in the semiconductor manufacturing, software and automotive industries. He has an MBA in Business Management and Ph.D. in Electrical Engineering.

ASK THE EXPERT

CUSTOM ELECTRIC REPLACEMENT FOR HYDRAULIC SCREWMOTORS IN INJECTION MOLDING MACHINES

By Thomas Czeppel, Manager EM Systems, Moog Germany

One trend in the plastics industry is the use of electric servomotors on the plastisizing axis on injection molding machines that are otherwise hydraulic. This offers significant energy savings due to the higher efficiencies of electric devices compared to hydraulically operated solutions. Some additional benefits of the electric replacement of hydraulic motors are:

- Higher Productivity: Allows for parallel movement of the axis along with shortened machine cycles, resulting in higher productivity
- Higher Quality: The parallel operation can be used to extend the plastisizing time at a given machine cycle, leading to improved thermal balancing of the melt and therefore producing higher quality parts
- Reduced noise levels
- Precise reproducible metering

Electric Screwmotor

The major challenge when designing an electric motor for hydraulic machines is to fit the envelope size provided in the machine. The energy density of hydraulic motors defines existing mechanical machine interfaces. Consequently, it was necessary for Moog to create a special, customized electric motor design.

Other design challenges involve the need for continuous power requirements in conjunction with the restricted envelope size. The Moog solution features water-cooling to optimize the heat dissipation. In comparison to convection-cooled servomotors, the unit will dissipate the losses up to three times better. Standard off-the-shelf solutions are cooled at the motor housing, leading to bulky mid sections.

The Moog solution integrates the cooling within the standard motor flange dimensions. The long and slender design allows machine integration thereby avoiding changes to the existing machine structure. The mechanical interface of the device allows for direct replacement of the hydraulic motor. The envelope of the system is further reduced using a single stage gearbox to match the ability of the motor running at fairly high speed to the low speed requirement of the axis. Power requirements as function of 2*Phi*Torque*Speed can cost-effectively be generated by the motor speed.

The life expectancy of the system is strongly related to the bearing life and quality of the gearbox lubrication. The placement of the cooling between the gearbox section and the motor in the Moog solution results in higher life expectancies through lower thermal temperatures of the lubrication, which is directly related to the lubrication life. Keeping the gearbox temperature low will reduce the wear of the shaft seals due to limited internal gearbox pressure levels. The sealing life, the contamination of the lubrication and the overall gear life are related. The calculation of the operating life of the system is targeted to the expectations of injection molding machine manufacturer. With that goal in mind, the redundancies of motor and gearbox bearings were eliminated by Moog in favor of a single integrated architecture.

In addition to the technological benefits of the electric solution described above, the Moog electric screwmotor provides extended machine availability and ease of integration.

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 currently pursues an MBA at the SIMT in Stuttgart.

NEW DIRECT DRIVE PERMANENT MAGNET ROTARY SERVOMOTORS FOR HIGH TORQUE APPLICATIONS

By Daisuke Okada,
Manager, Products Engineering & Technology

In response to growing demand for more efficient solutions for larger machines, Moog is introducing a new line of flexible high torque, direct drive servomotors. Moog's large direct drive permanent magnet rotary brushless servomotors are ideal for processes requiring high peak or rated torque.

By eliminating components such as gearboxes and belt drives that are prone to wear, direct drive rotary servomotors improve accuracy and repeatability, enable reduced machine size, offer higher efficiency resulting in energy savings, minimize maintenance costs and downtime, and produce quieter operation.

Moog's Direct Drive Servomotors are suitable for some of the most demanding applications in the plastic market such as the injection and clamp axes.

- Injection Axis: Compact design, high power, high velocity response, and unsurpassed speed control
- Clamp Axis: Simplified design without gearbox, allowing higher speed and smoother operation.

These servomotors are used in many metal forming and press applications as well such as the punching axis of the turret punch press.

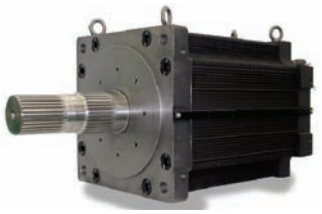
Benefits of Moog's Direct Drive Permanent Magnet Rotary Servomotors

1. *Better dynamic performance for more accuracy during high-speed operations.*

Moog's Servomotors provide the best available direct drive dynamic response. They combine the highest available peak torque with the lowest moment of inertia resulting in better acceleration and deceleration for improved accuracy during high-speed operation. Compact stator designs reduce overall motor size by at least half the moment of inertia of competitor models, and our unique coil designs produce high peak torque, giving these motors the world's highest power density per unit volume currently available.

2. *Flexible design for easy machine integration and better performance*

Moog will adapt the characteristics and packaging of these motors to provide higher performance and machine design flexibility than previously possible. For instance, the stator design can be adapted to maximize peak or rated torque depending on the application. The hollow shaft can be enlarged to pass cables through or house mechanical components, and every kind of shaft and hollow shaft configuration can be accommodated, including flange, spline, key, and thread. Other options include multiple types of bearing, various feedback devices, and alternative cooling methods.



Moog's ability to customize both the performance and packaging of these servomotors will enable OEMs to develop higher performance high-power industrial machines with innovative designs where electromagnetic direct drive servo technology is not yet commonly used.

About the Author:

Daisuke Okada, Manager, Products Engineering & Technology, is responsible for electro-mechanical actuators and the direct drive servomotor for Moog in Japan. He has worked for Moog since 1992 as an application and design engineer of hydraulic products as well as a designer of electro-mechanical actuators during his 2-year assignment with Moog in the US.

HOT WEBSITES

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http://www.plasticstrends.net

The Plasticstrends website brings you articles by scientists and industry experts. Specializing in "what's hot and new" in plastics, this site offers in-depth information for machine builders.

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IDES is a plastic materials information company with a vertical search engine for the plastics industry. This website provide tools for plastics professionals to quickly access technical plastic materials information and data.

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