MOVING YOUR WORLD
IDEAS IN MOTION CONTROL FROM MOOG INDUSTRIAL
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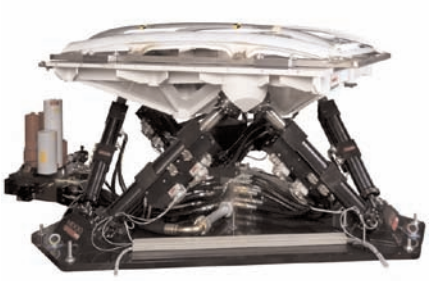
MOOG

CAR ROOF RACK MAKER THULE TWISTS AND TURNS WITH NEW MOOG FCS TEST RIG

By Pim van den Dijssel, Market Development Manager, Test at Moog FCS



Moog FCS Thule Test Rig

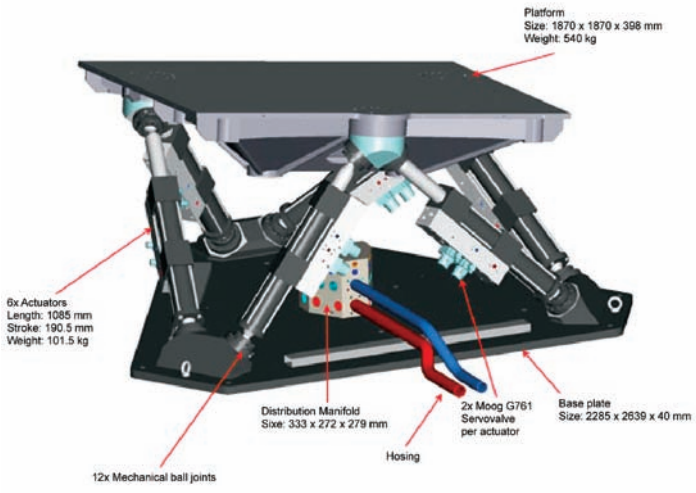
If you've ever had to carry bicycles, skis or even a surfboard on the roof of your car, you likely know the Swedish roof rack maker Thule. For those who've hauled bikes or luggage on a road trip, a strong, reliable roof rack is indispensable equipment. And now Moog FCS is helping to make that even more so.

Moog FCS' work for Thule is all about ensuring their new products are every bit as dependable as its existing ones. So, in February 2008, Thule - the world's leading supplier of car rack systems - picked Moog FCS to supply a test rig, a very special one. The test system simulates the conditions Thule's products face when fastened to the roof of a car. Whether you're racing to the beach with a surfboard strapped to your Thule roof rack, or facing buffeting winds in a mountain pass with luggage atop your SUV's rack, Moog FCS' test rig simulates the twists and turns of the road.

Moog FCS delivered its test rig just in time for Thule to throw open their doors to a new test facility in Hillerstorp, Sweden. Moog FCS' test system will occupy a special place inside the facility that Thule's worldwide operations rely on to ensure the quality of its products.

Thule needs to establish that its car roof rack or box stays firmly attached to a vehicle and that it stays in one piece. So, among other things, Moog FCS will be testing the product's clamping device as well as the rack or box.

Tests are done with the clamping units attached to a car roof provided by the OEM. According to Thule Technical Group Manager Fredrik Larsson, car makers are increasingly calling for sustainability tests on the original equipment.



The MAST Hexapod

Reflecting on why Thule chose to work with Moog FCS, Larsson said, "We liked their technical solution. They were very easy to work with, and their expertise in testing helped us to develop our approach.

Moog FCS Test System Tears a Page from Flight Simulation

Moog FCS delivered Thule the complete test rig, including a Multi-Axis Shaker Table (or MAST), unlike any on the market. Moog FCS' design stemmed from work it had done with flight simulators. Rather than building a conventional orthogonal system, which has a table moved by actuators mounted on its base and sides, the Moog FCS HexaTEST MAST is a six-legged hexapod. The hexapod has two equilateral triangular frames set one above the other, offset at 30 degrees. Each apex of the top triangle is connected to the two apexes below it on the lower triangle via Moog FCS actuators.

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Along with the MAST, Moog FCS supplied the seismic mass, hydraulic infrastructure and safety system. Moog FCS also provided the data acquisition set-up, including the control cabinet and operator software.

The software package includes Moog FCS' SmarTEST program for system installation, and FasTEST operator software for running tests to simulate travelling over various road surfaces

Hexapod Technology Bests the Competitors' Performance Specs

Moog FCS examined what the competition could do in terms of acceleration and displacement as a benchmark, and set out to beat its competitors' performance specifications. While the hexapod is a proven technology, Moog FCS is the first company to use it in this kind of application.

Moog FCS developed the HexaTEST MAST over four years. The system has six degrees of freedom (DOF) wherein the table moves in the x,y and z axes, with pitch, roll and yaw. It's complex to control each of the individual degrees of freedom because a movement along a single axis involves the use of all six actuators. All the actuators have to be controlled exactly in terms of speed and time, and this is tricky when the table has to vibrate at frequencies between 0.8 to 80 Hz.

As for the hexapod's advantages, there are many. MASTs need to be anchored in a "seismic mass," a massive concrete block that contains vibrations within the apparatus. The smaller the MAST, the smaller the concrete block needs to be. The hexapod MAST can operate in a space three to four times smaller than competing designs. Even so, the block for Thule's hexapod weighs 88 tons. The new unit is also less costly to maintain than orthogonal designs because its six actuators are alike, so spare parts cost less.

For the MAST to run at very low frequencies, the seismic mass incorporates "active level control." Air springs under the MAST automatically activate as the mass begins to resonate, compensating for its motion. The MAST can vibrate with amplitude of over 140 mm along its axes, while maximum rotational displacement is +/- 10 degrees. It supports loads of up to 990 lbs. And it can run continuously for several days, a period equivalent to hundreds of thousands of road miles.

Moog FCS Test System "Hits" the Road for Thule

In the weeks since buying the test rig, Thule has already carried out several simulations.

"We are very happy with the test system; it's compact, clean and very simple to use," said Larsson.

For example, all of the system's hydraulic hoses are embedded in the concrete floor. The system provides flexibility, too. Tests are currently done at ambient temperatures. But the rig can operate at various temperatures if Thule decides to install a climatic room. And if Thule does needs additional support with its newly deployed Moog FCS test system, Larsson isn't worried.

"If we do run into trouble, Moog FCS has people close by in Gothenburg. We know we can count on them to quickly come in and help out," Larsson said.

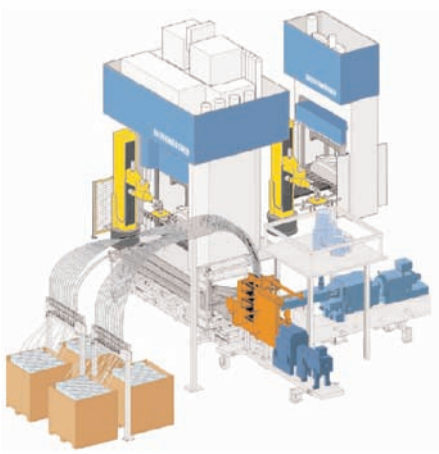
In addition to testing roof racks, Moog FCS has sold its MAST to examine passenger and industrial vehicles. Moog FCS supplies a number of large OEMs throughout the world with testing solutions. In general, Moog FCS excels in developing applications that require engineer-to-engineer collaboration to provide a leading-edge solution. Moog FCS' work for Thule is simply the latest chapter in a collection of stories about innovative testing.

About the Author:

Pim van den Dijssel is Market Development Manager, Test at Moog FCS based in Nieuw Vennep, Netherlands. He is responsible for developing the aero and auto test businesses in Europe working together with his colleagues in Asia and America. He holds a Bachelor degree in Industrial Automation from the University of Utrecht, Netherlands, and has over 15 years experience in aero test solutions.

HIGH OUTPUT, HIGH RELIABILITY, LOW ENERGY CONSUMPTION IN A PLASTICS PRESS WITH MOOG MOTION CONTROL TECHNOLOGY

By Volker Treffler, Engineering Manager, Moog Luxembourg



Plastics press for fiber reinforced plastics

Controlling motion in a press that is 3 stories high, exerts forces of 36,000 kN (8,000,000 lbf) and that completes a cycle in 19 seconds is a significant challenge for any metal forming company. To make it even more complex, this machine is used for producing some of the latest plastics materials such as car doors, panels and even whole cars that require exacting quality right off the press. Dieffenbacher and Moog have worked together to realize these technical requirements and also provide additional benefits such as energy savings, remote diagnostics and support.

This article focuses on the latest generation plastic press from Dieffenbacher, a leading manufacturer in the field of SMC/GMT/LFT technology based in Germany. SMC/GMT/LFT technology is a process for fiber-reinforced plastics used for manufacturing complex lightweight components. Crash-resistant lightweight structural components with a cosmetic surface are manufactured on this machine from advanced plastic compounds producing exceptional finish quality.

Moog has been developing and supplying hydraulic systems including integrated hydraulic manifold systems and advanced valves for high-performance metal forming presses for over 10 years. The machine called the COMPRESS PLUS from Dieffenbacher is their response to the needs of their customers to be more competitive, productive and cost effective

Parts for the automotive industry

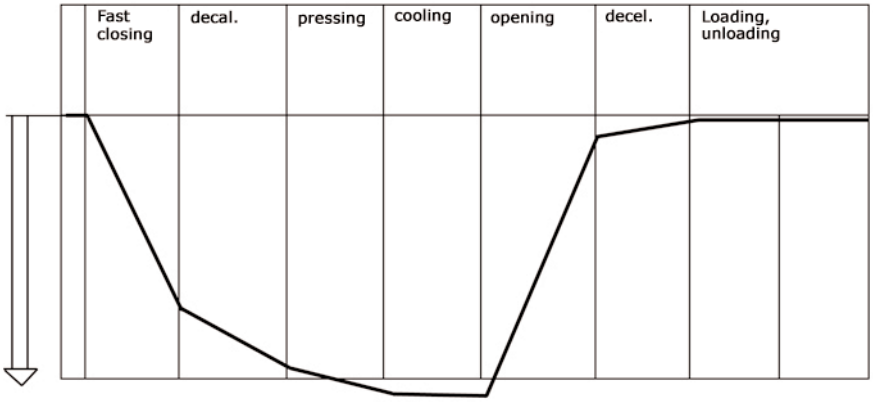
Customer Benefits of COMPRESS PLUS

Plastic presses are for direct processing of fiber-reinforced thermoplastic and thermosetting plastics. This is a challenging high production application that is often used in automotive manufacturing of large components such as doors and panels.

- **Energy:** In response to steadily increasing energy prices, Dieffenbacher and Moog, developed a machine that reduces energy consumption up to 50% by means of a new closing device and an optimized hydraulic concept.
- **Quality:** The new generation press enables the end customer to produce parts of highest quality due to an innovative high performance motion control solution. The increased stiffness of the hydraulic system and the use of high responseservovalves with digital electronics guarantees high precision and repeatability of the control axis.
- **Reliability:** The control concept is based on fieldbus technology. Servovalves and sensors are equipped with EtherCat Interface that enable diagnostics and support remotely via the Internet.
- **Cost:** In order to address the increasing cost pressure of the customers, the new generation press combines high output, high reliability, low energy consumption and an attractive price-performance ratio in one machine.

Technical Specifications for Speed and Force

One of the challenges of this application is speed where complex motion must occur at extremely rapid rates.



Cycle time: 19 seconds

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Figure 1 - Shows an exemplary press cycle for an 36,000 kN (8,000,000 lbf) press closing time 4 sec., pressing time and cooling 6 sec., opening time 4 sec., loading/ unloading time 5 sec.

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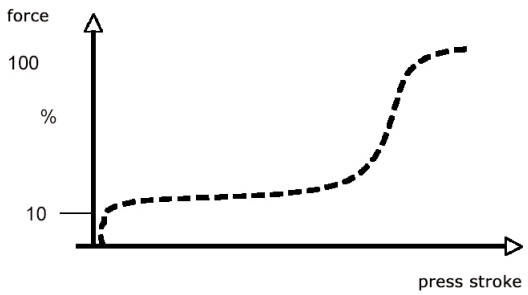


Figure 2 - Force Stroke Characteristics

The weight of the mold is approximately 60 ton and the closing movement is driven by the gravity force and no energy is required. During 90% of the pressing cycle, only 10% of the maximum force is required. Figure 2 shows the force- stroke characteristics.

This means that the maximum pressing force is needed for a short interval of the process cycle. Typically vertical hydraulic presses are equipped with a fast stroke auxiliary cylinder (also known as a kicker cylinder) to control the speed and position of the upper die in combination with the main press cylinder precharged with the use of prefill valves and a tank that is on top of the press. The maximum speed of the upper die cylinder is limited by the size of the prefill valves.

New Press Design

An analysis of the process parameters like force and speed was conducted, resulting in a new optimised press design concept. Figure 3 illustrates the principle of the new design of the hydraulic system.

In its new design, Dieffenbacher overcame the conventional limitation with a new upper die concept, where a mechanical locking device is transmitting the press force from a short stroke cylinder. This eliminates the need for prefill valves and the prefill tank, thereby reducing costs and increasing the maximum closing and opening speed.

Technical data of a 36,000 kN (8,000,000 lbf) press COMPRESS PLUS:

Speeds: fast closing, opening	1,200 mm/s (47 in/s)
Speed Pressing	1- 80 mm/s (.04 -3.5 in/s)
Flowrate	max. 3,300 L/min (872 gpm)
Press force at centric load	2,000 mm (78.73 in)
Press force at maximum parallel levelling force	32000 kN (7,200,000 lbf)

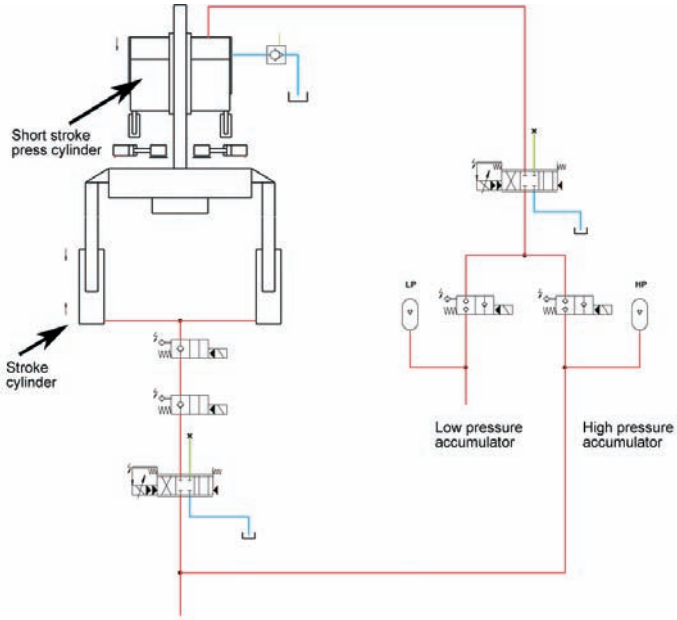
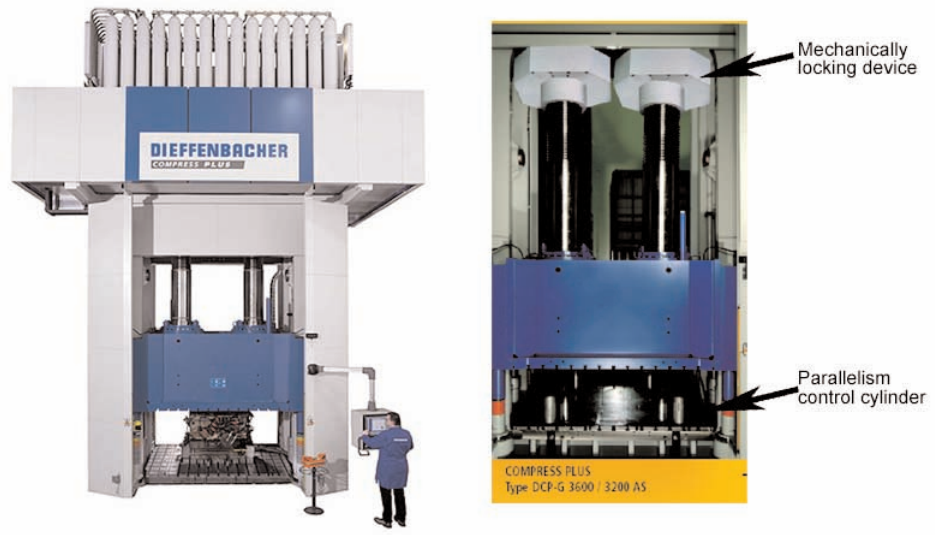


Figure 3 - Principle of the hydraulic system



New Press Design COMPRESS PLUS, Dieffenbacher, with short stroke press cylinder and mechanically locking device

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Main Advantages of the New Concept

Due to the short stroke press cylinder the oil volume is reduced significantly. This leads to increased stiffness and higher natural frequency of the hydraulic system.

The use of a servo-proportional valve with integrated failsafe functionality in combination with a position-monitored active cartridge fulfils the press safety requirements. The main stage of the servo-proportional valve is spring centered, when the failsafe directional valve is switched off by the machine control. The electronics detects the safe position within a safety window and generates a logical signal (> 8,5 V), that is available on the main valve connector.

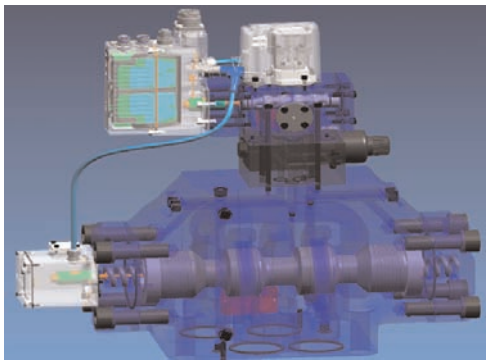
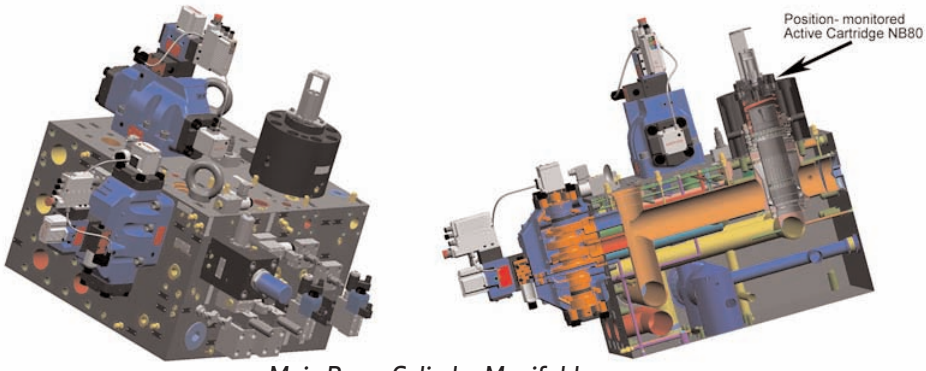


Figure 4 - 3-stage Servo valve D675 with digital electronics, EtherCat Interface and failsafe function

- *Servo-Proportional Valve Dynamic Data:*
- *100% step response in less than 35 ms*
- *90° phase lag at 90 Hz with 5% command signal and 140 bar (2,000psi) pilot pressure*

Due to the active cartridge design a closing time of less than 150 ms to switch off the accumulator circuit is achieved thereby meeting Machine Safety Standards. This concept allows a compact manifold design with less hydraulic components and intersections. Low pressure drop in the hydraulic circuit improves the efficiency of the hydraulic control circuit.

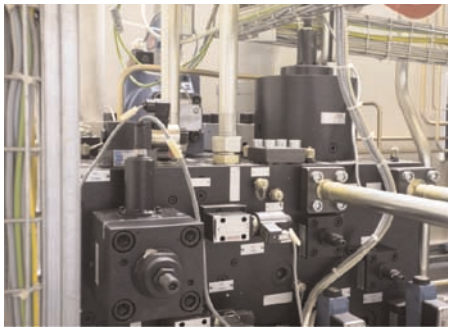


Main Press Cylinder Manifold

In addition, the adaptation of system pressure with a low pressure and high pressure accumulator reduces significantly the pressure losses during the pressing mode. Depending on the force requirements the high-pressure accumulator is activated for the final pressing stroke only.

Conclusion

Moog Industrial Group and Dieffenbacher collaborated on an innovative new solution for a latest generation plastic press that significantly reduced the energy consumption and met tough technical challenges to increase the productivity and reliability of the machine. The combination of a new mechanical design of the closing device with a customized hydraulic control concept meets the future requirements of customers in one of the most demanding and advanced applications involving high forces and speeds as well as exacting finished part quality.



Installation in the Press

About the Author:

Volker Treffler is the Engineering Manager of Moog Luxembourg based in Bettembourg. Employed since June 1995, he is responsible for developing manifold systems solutions and cartridges valves. He holds a Master of Science degree in Mechanical Engineering from the University of Krefeld (Germany) and has over 25 years of experience in hydraulic systems for presses and injection moulding machines.

FASTACT G-SERIES SERVOMOTORS – NEW ADDITIONS TO AN OLD FAVORITE

By Andrew Barrett, Product Line Manager for Industrial Servomotors

New G411 Servomotor –
The Smallest High Performer

Fastact G Servomotors are known as the choice for highly dynamic servo applications where positioning times of 30 msec or less are often the norm. Moog continues to enhance this product line with additions such as the new Fastact G Size 1 motor that adds the 40 mm flange size to the existing product range and improvements such as expanded encoder feedback options.

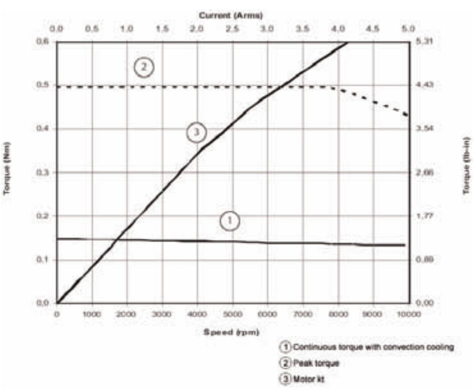
In response to needs in the marketplace, Moog developed the G4-1, a low voltage (325V) servomotor that comes with the standard options such as a brake, encoder/resolver choices and various shaft options. All this flexibility comes with the exceptional performance as shown in table 1. Now The G-Series range goes from a size 1 (40 mm flange size) to a size 6 (190 mm flange size) with the following performance range:

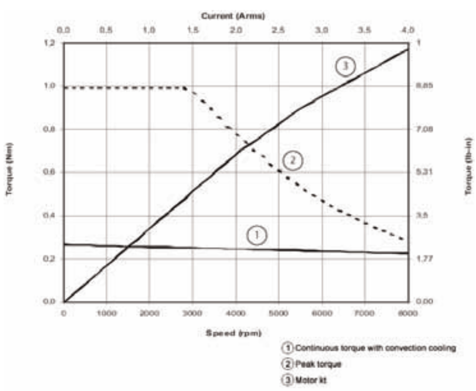
Category	Symbol	G4-1			Units
Stack length (in mm)	-	L20	L40	L60	-
Nominal Torque, continuous duty, locked rotor	MO	0.15 [1.3]	0.27 [2.4]	0.37 [3.3]	Nm [lb.in]
Nominal speed	nN	9000	6000	6000	rpm
Max torque	Mmax	0.5 [4.4]	1 [8.9]	1.5 [13.3]	Nm [lb.in]
Nominal torque, continuous duty, nominal speed	MN	0.14 [1.2]	0.2 [2.1]	0.3 [2.7]	Nm [lb.in]
Output power, continuous duty, nominal speed	PN	0.13 [0.18]	0.15 [0.20]	0.19 [0.25]	kW [hp]
Rotor inertia (resolver included)	J	0.023 [0.2]	0.045 [0.4]	0.068 [0.6]	Kgcm2 [lb-in.sec2 x102]
Torque constant	kT	0.17 [1.5]	0.34 [3.0]	0.46 [4.1]	Nm/Arms [lb-in/Arms]
Thermal time constant	tTh	600	650	700	Sec
Winding resistance at 25°C (phase to phase)	Rtt	23.0	34.8	37.0	Ohm
Weight (without brake)	m	0.55 [1.2]	0.68 [1.5]	0.82 [1.8]	Kg [lb]

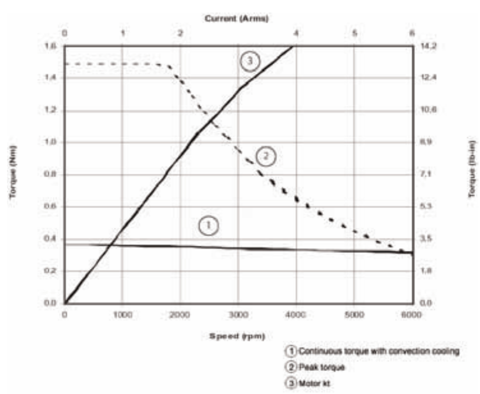
Notes:
1. Motor performances as measured with Moog's servodrive of proper size
2. Rotor inertia: with resolver, no holding brake

Table 1 - Performance Specification for Standard Models

Performance Curves







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Expanded Feedback Options for Greater Flexibility

With the growing requirements for encoder feedback in industrial markets, Moog is now offering various encoder feedback options on our high-performance Fastact G Servomotors. Our application experts work with customers to identify which technologies are the best for their applications.

Selecting Resolver or Encoder Based Systems

When the environment has hot, very cold, humid, oily, high vibration/shock, dusty or other beyond normal industrial conditions, a resolver-based system is the preferred choice.

When precise positioning, smooth torque and stable velocity control are top priorities for the application, the encoder-based system is the preferred choice. Encoders typically have all their electronics onboard, minimizing interconnections, but limiting operating temperatures.

In determining whether to use a Moog servomotor with a resolver or encoder, close consideration of the application under the characteristics shown in table 2 is required. All factors must be balanced for the right design fit.

Specifications: Encoders vs. Resolvers

Category	Resolver	Encoder
Angle measurement	Absolute	Absolute/Incremental
Absolute resolution	16 bits	13 bits
Incremental resolution	N/A	10,000 lines/revolution
Accuracy (arc minutes)	4 to 40	0.25 to 6
Electronic interface	R/D converter	Direct
Noise immunity	Sensitive	Best
Output signal	Analog	Analog/Digital
Construction materials	Robust	Fragile
Weight	Heavy	Lighter
Inertia	High	Low
Longevity	Very High	High
Shock/vibration	Rugged	Limited
Temperature Range	-50 ºC to +150 ºC	-20 ºC to +100 ºC
Contamination	Immune	Vulnerable

Table 2: Encoder v Resolver Application Considerations

Selecting Encoders

In determining which type of encoder to use, the initial choice is to determine whether to use an absolute or incremental encoder.

Incremental encoders have output signals that repeat over the full range of motion. It is important to understand that each mechanical position is not uniquely defined. When the incremental encoder is turned on, the position of an incremental encoder is not known since the output signals are not unique to any singular position.

Absolute encoders report absolute positional information. When powered up, it does not require a home cycle, even if the shaft was rotated while the power was off. If an absolute encoder is chosen, the further choice is whether to use a single-turn (unique position information within one revolution) or multi-turn (unique position information beyond one revolution) absolute encoders.

Table 3 below shows the encoder option sizes available by servomotor front flange sizing.

TYPE	MFG	Size 1(40 mm)	Size 2 + 3 (55 + 70 mm)	Size 4(100 mm)	Size 5 + 6(140+190 mm)
Incremental	STEGMANN	-	CKS 36	CNS 50	CNS 50
ABS Single Turn		-	SKS 36	SRS 50	SRS 50
ABS Multi Turn		-	SKM 36	SRM 50	SRM 50
Incremental	HEIDENHAIN	-	ERN 1185	ERN 1387	ERN 1387
ABS Single Turn		ECN 1113	ECN 1113	ECN 1113	ECN 1313
ABS Mutli Turn		EQN 1125	EQN 1125	EQN 1325	EQN 1325

Table 3. Encoder options by servomotor flange size

About the Author:

Andrew Barrett, B.E.(electrical), M.Eng.Sc. (control electronics), MBA, is a Product Line Manager for Moog's Industrial Servomotors. He brings 15 years of experience in engineering, operations and product line management, gained during a career with several multinational companies.

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