INDUSTRIAL NEWSLETTER

MOOG

Issue 2, November 2003

Did You Know? | Hot Websites | Product Spotlight | Ask the Expert | Upcoming Events | Contact Us

Achieving High Speed and Precision

Customized Solutions for Machine Builders

Real improvement in machine performance is the goal for Moog when developing a solution for our customers. A machine builder named Morphic Technologies (www.morphic.se), based in Sweden, is an ideal example of Moog's ability to design a custom solution that achieves vastly better results than have ever been experienced with their machine. This was accomplished through a partnering relationship that involved applying experience in motion control, and using custom hydraulic and electric products in a wire cracking machine. The challenge in this application involved achieving very high speeds and precise accuracies to create parts that are perfect every time.

The expertise of Moog's global engineering organization in hydraulic, electric, and hybrid technology was a perfect match for Morphic Technologies, as their machine has a hydraulic impact axis and an electric feeding axis. A special customized servomotor and the new high performance DS2100 servodrive were used for the electric axis that controlled the speed of the machine. In addition, the Moog Servo Controller (MSC) was the perfect product to control the three high performance axes. The MSC also proved to be a money-saver as Morphic was able to eliminate the existing PLC. Most importantly, the ultimate solution, not only met but exceeded the customer's demanding project goals.

The Application

The core competency of Morphic Technologies is the development of technology and systems for precision steering of extreme dynamic forces. One of its premier products is a wire cracking machine that is used by manufacturing facilities around the world for high quality wire cracking. The principle of operation for this machine is a metal wire that is fed through two tight fitting rings with orifices aligned in a row (cracking dies). One of these dies is hit with a huge impact (comparable to a hit with a hammer), while the other is kept in position. This causes the wire inside to crack due to the huge shock impact. Although the impact may cause only a movement of 1 mm, a wire of even 25 mm in diameter will crack through immediately. The result is a perfect surface instead of a traditional shear cut.

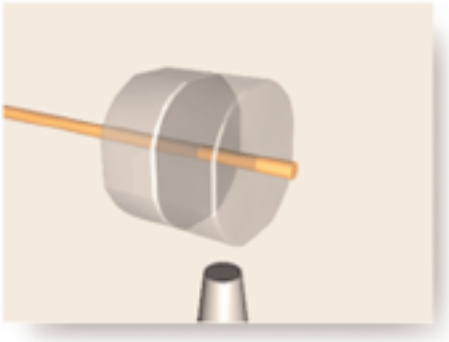


Diagram of the Wire Cracking Principle

The Challenge

The challenge for the Moog - Morphic partnership was to create a machine capable of cracking wires up to 25 mm in diameter at the incredible speed of 800 to 1000 pieces per minute (The sound created is similar to a machine gun). Also required was precise control to allow maximum flexibility for wire size, impact control, feeding length, and accuracy. This way the cutting machine can be sized correctly and does not need to be oversized. The control of the impact provides quality control, extended lifetime of the tools, and higher reliability for users.

These technical objectives were achieved and improved upon with the Moog solution. Due to the flexibility of the Moog Servo Controller (MSC) in providing motion and sequence control, the existing PLC was eliminated and all operations are now controlled through by the MSC and one operator's panel. This is unique for cutting machines and enables quicker setup and easier adjustments for cutting length, speed or impact force. The overall package is easier to use, more productive, and highly flexible.

The Solution

Hydraulic Impact Axis:

Moog Products:

- MSC for control
- RKP Pump -Radial Piston Pump
- Servo-Proportional Flow Control Valve

For optimal cutting quality and performance, the kinetic energy from the impact ram needed to be controlled. The optimal energy level depends on the type and profile of material, which can range from soft copper to hardened steel. The impact itself is created by a fast and precisely controlled hydraulic cylinder. The Moog Servo-Proportional Valve controls a special valve developed by Morphic (patent app.) arranged inside the cylinder. This allows for 100% step response in only 5 ms. For optimum timing, the movement needs to be damped immediately after the hit and moved back to original position to allow further feeding of the wire. The complete movement (impact, damping and move back) is realized in less than 20 ms.

Electric Feeding Axis:

Moog Products:

- Two customized G400 Series *Servomotors with Stegmann Absolute Encoder (SRM50)
- Two new DS2100 Servodrives
- MSC for control

The feeding unit is vital as it defines the speed capability of the machine. Two clamping units feed the wire alternately and each is controlled by a rack and pinion system using two Moog G400 series servomotors. The project specification was to achieve a continuous duty cycle (clamping, acceleration, deceleration, fine positioning) in only 80 ms, and to obtain fine positioning accuracy of 0.05 mm.

Servomotor G400 Series

To achieve this speed, a special custom servomotor was optimized for the application. The customization allowed for the motor to be directly coupled to the actuator, removing the need for a gearbox. It also provided for the necessary high levels of torque needed to overcome the high inertia forces for acceleration and deceleration. To realize the required accuracy a high resolution feedback device was required, so the servomotors were equipped with a Stegmann encoder (SRM50) instead of the traditional resolver. The encoder delivers both commutation and absolute position signals.

The very fast position control loop of the electrical axis is closed inside Moog's new high performance DS2100 Servodrive. This powerful and flexible servodrive provides a wide range of interface options, which included the necessary interface to the high resolution optical encoder. Tests performed with this machine resulted in an absolute error less than 0.001 mm within 150 ms. The target 0.05 mm accuracy was reached with a duty cycle time of only 60 ms.

Moog's solution realized the accuracy of 0.05 mm and speed of only 60 ms for a 50 mm movement with a fine positioning accuracy that was even better than required. This is a new record in speed.

Servodrive DS2100

Machine Control with Moog Servo Controller (MSC)

Moog Products:

- Moog Servo Controller (MSC),
- Moog Axis Control Software (MACS) development environment
- QAIO and QDIO, input-output extension modules

Motion Controller MSC
Morphic needed to find a more powerful machine controller for the high performance axis. The Moog MSC was the perfect answer as it even had enough processing power to handle other "miscellaneous" PLC functions. The MSC is now the only control inside the machine for both PLC and Motion Control. Specifically it controls the following functions:

Motion Controller MSC

- High performance hydraulic axis
- Two high performance servomotor axes
- User interface, keyboard, and terminal
- Various input switches and signal lights
- Safety switches and monitoring sensors
- Temperature control
- Hydraulic pump and pressure control with oil temperature monitoring
- Preheating zone for wire

To realize all these features the MSC needed extended I/O's, which are available as click-on modules from Moog's M3000 System portfolio. All the M3000 modules are software configurable. Morphic chose one QAIO (analog I/O) and two QDIO (digital I/O) modules.

All high speed motion controls, as well as all the PLC functionality in the machine, are controlled by the Moog Axis Control Software (MACS). Morphic's staff implemented the machine control software easily, even without any formal training, as they knew the IEC61131 languages upon which the MACS is based. Using the Moog function blocks and Moog's PLCopen motion library made their task even easier.

Moog Servo Controller (MSC) and Extension Modules

Conclusion:

Morphic Technologies' cutting machine is a truly unique product in the market, largely due to its approach to control. Through innovation, the company delivered a fast and accurate machine to meet their customers' needs. Moog worked together with Morphic to apply its expertise in motion control and develop custom versions of its high performance servomotors and servodrives.

Moog is equally skilled in providing motion control solutions in hydraulic, electric or combined technologies. The effective implementation of the easy-to-use Moog Servo Controller was another key component to an overall solution that not only met, but exceeded the expectations of the demanding application - an accuracy of 0.05 mm and speed of only 60 ms. Breaking records is routine for world class partners like Moog and Morphic.

About the Author:

Jürgen Weiblen, Manager Controls Product Line
Jürgen has been working with Moog for more than 11 years, starting with servomotors and servodrive engineering and later heading the Moog GmbH Research and Development department. Today he has worldwide responsibility for Moog's Industrial Controls product line. He has a University degree in Electronics (Diplom Ingenieur).
performance motion control products.

Appendix A

Machine Location	Description of Wire Cracking Machine
Left	Wire feeding (straightening unit removed)Wire size up to 25 mm in diameter
Middle left	High performance electrical feeding unitFeeding distance used: 40 mm (but can be higher)Feeding accuracy: +/- 0,05 mmCycle time per feed: approx. 60 msec
Middle Right	Wire heating unit: Required for hardened wires
Right:	Human machine interface with monitor and keypad etc.Hydraulic cracking unit is located vertically behind the monitor (cycle time for movement approx. 20 ms)

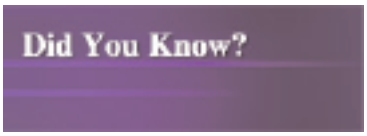
Morphic Technologies' Wire Cracking Machine

See Also:

- **Industrial Contacts/Distributors**
- **Industrial Systems Capabilities**
- **Servomotors and Servodrives**
- **MACS- Moog Axis Control Software**
- **MSC - Moog Servo Controller**
- **M3000 Systems**
- **RKP Pumps**
- **Servo and Proportional Valves**

Did You Know?

Inertia and Motors



What is a simple definition for "moment of inertia," often described as inertia in a motor?
Inertia describes the tendency of a body to resist changes in rotational speed for a given torque.

What is a typical ratio of the application load inertia to the motor inertia?
It is not unusual that the application load is in a range of 1:1 to 5:1 to allow highest loop bandwidth and dynamic response. The “inertia mismatch” is a rule of thumb indicator for good controllability of the axis. For a ratio of 1:1 the necessary torque during acceleration is equally applied to the load and the motor.

Why do low inertia motors benefit an application?

- Minimizes torque requirements and consequently can effect drive selection.
- Motor selection is usually smaller in envelope and drive selection could require a lower continuous current rating.
- Performance of machine can be improved (e.g., throughput)

Why is rotor inertia important to know?
A motor can not be selected for replacement by the power rating or the torque speed curve alone without knowing how the rotor inertia has effected the continuous torque required in the application.

For more information, contact the Moog Electric Drives Division in:
For more information, contact the Moog Electric Drives Division in:

Italy: **sales.italy@moog.com**

USA: **sales.icd_elec@moog.com**

Germany: **sales@moog.de**

Japan: **sales@moog.co.jp**

Hot Websites

globalEDGE™ (www.globaledge.msu.edu/)

globalEDGE™ is a knowledge web-portal that connects international business professionals worldwide to a wealth of information, insights, and learning resources on global business activities.

BINCS (Business Identification Number Cross-reference System) (www.dlis.dla.mil/bincs)

BINCS is a search engine of manufacturers and suppliers. Information in this system is cross-referenced to permit inquiry by CAGE, DUNS, UPC, Company Name, Phone Number, SIC Code and ZIP code. Located on the Defense Logistics Information Service webpage.

Product Spotlight

M3000 Systems

The M3000 System is Moog's high performance digital motion control system for hydraulic and electric drive products. The M3000 is built to enable users to easily implement fast and accurate control structures. A powerful control system enables complex multi-axis functions with axis cycle times of one millisecond or even faster closed-loop control with servovalves or servomotors. A variety of extension modules are available for the MSC (Moog Servo Controller) as part of the M3000 System. Each is mounted on a DIN rail for easy add-ons and a high degree of flexibility.

Moog Servo Controller (MSC)
The core of the M3000 system is the Moog Servo Controller (MSC), a freely programmable multi-axis controller that enables simultaneous advanced control algorithms and PLC sequencing in a single application.

Key Features

- Advanced digital motion control for closed-loop control (e.g. position, speed, force) of hydraulic and electric products.
- Use of accepted standards and protocols insures fast implementation and easy set-up to save users time and money.
- 32-bit RISC processor with Floating Point Unit for powerful, fast and accurate control.
- Multiple software configurable interfaces: SSI,Encoder, CANopen, RS 232, Ethernet, Profibus, analog/digital outputs and various serial interfaces.

Moog Axis Control Software (MACS)
The Moog Axis Control Software (MACS) is an IEC 61131-3 Development Environment for the MSC and hardware configuration for all M3000 modules. It is an all-in-one software with programming, debugging, simulation, parameterization, visualization and tracing capabilities. MACS uses universal protocols and offers all textual and graphical programming languages which are defined by IEC 61131-3 (Function Block Diagram, Instruction List, Sequential Function Chart, Structured Text, Ladder Diagram, Continuous Function Chart). Moog also specializes in developing easy-to-use, customized control algorithm function blocks for MACS.

Key Features

- User friendly IEC 61131-3 programming tool based on the **CoDeSys Automation Alliance** quickly becoming the global standard for machine builders.
- Simultaneous combination of advanced control algorithms and PLC sequencing.
- Includes libraries with function blocks for closed-loop control, filters, signal conditioning, communication, PLCopen function blocks and many others.
- Uses universal standards with protocols such as CANopen, TCP/IP, DDE, and OPC.

For more information, click on **M3000, MSC** and **MACS**.

About the Author:

Dieter Kleiner, Hydraulic Controls Engineering, Moog GmbH
Dieter is responsible for customer support of M3000 products. He has been working software development projects for control systems used in industrial and military applications.

Ask the Expert

PID Control

Background:
The PID controller has its origins within the process control industry going back over 50 years. Today it remains an industry standard in this and many other applications, including hydraulic servodrives.

In the early days, the 3 terms of the controller P, I & D, ((P)ropotional, (I)ntegral, (D)erivative) were implemented in analog electronics. Hence the commonly used name “3 Term Controller.” More recently, digital (microprocessor based) closed-loop electronics have become commonplace. However, the PID controller concept has remained intact as the means of achieving closed-loop control in hydraulic servo systems.

What is PID Control and what role does each term play?
The abbreviation PID is descriptive of the action taken by the controller in achieving high accuracy and/or fast and stable dynamics in a closed-loop system. In the standard configuration (taking hydraulic drives as an example), the P, I, and D, terms act upon the system control error to produce a valve drive output signal which is a summation of the 3 components. These are produced in the following manner and have a distinctive action in the controller:

(P)roportional Algorithm

- Sets the proportional algorithm (P) output to a level depending on multiplying the error by a gain Kp
- Increases system static accuracy and dynamic response.
- Direct function of the error and gain setting Kp such that:

$$P = f[k_P \cdot error]$$

(I)ntegral Algorithm

- Increases the integral algorithm (I) output at a rate depending on the error multiplied by the integral gain Ki
- Gives further increase in static accuracy, but often at the expense of dynamic response.
- Function of the accumulation of error with time and gain setting Ki such that:

$$P = f[k_P \cdot error]$$

(D)erivative Algorithm

- Sets the derivative algorithm (D) output to a level depending on the rate of change of error multiplied by the gain term Kd
- Increases or improves the dynamic response.
- Function of the time rate of change of error and gain setting, Kd such that:

$$P = f[k_P \cdot error]$$

The optimum value for the 3 gains (Kp, Ki, and Kd) is normally found during the commissioning process and is dependant on the characteristics of the controlled system.

What if PID is not enough?
The wide acceptance of PID control as a standard makes it a good starting point for most servo control applications. However, a little extra in terms of control capability is often required to achieve a good result; for example when dealing with high inertia drives or particular types of load or pressure control. Moog has developed the M3000 and MSC (Moog Servo Controller) to deal with these issues.

To submit a question, click on **Ask the Expert**.

Upcoming Events

Please visit the Moog booth at:

- Fluid Trans Compomac in Milano, Italy (February 18 - 21, 2004)
- Taipei Plas 2003 - International Plastics and Rubber Industry Show in Taipei, Taiwan (March 18 - 21, 2004)
- Mecanelem-Mecatronic in Paris, France (March 22 - 26, 2004)

For more information, click on **Exhibits and Trade Shows**.

Moog Training Sessions

- 20-22 January 2004 Software training: Introduction to MACS / IEC 61131 Programming (2.5 days) English Lanugage Session held in Germany (near Stuttgart)
- 22-23 January 2004 MSC - Moog Servo Controller Hardware and Extension Modules Training (1.5 days) English language session held in Germany (near Stuttgart)

Contact Us

To find the location or distributor nearest you visit **worldwide locations**.

E-mail Newsletter

To receive an email version of future editions of this newsletter, click on **signup form**.

CONTACT INFORMATION

Argentina	tel: +54 (11) 4326 5916	fax: +54 (11) 4326 5916	sales.argentina@moog.com
Australia	tel: +61 3 9561 6044	fax: +61 3 9562 0246	sales.australia@moog.com
Austria	tel: +43 1 688 1384	fax: +43 1 688 1384	rlange@moog.de
Brazil	tel: +55 11 5523 80 11	fax: +55 11 5524 21 86	sales@br.moog.com
China	tel: +86 21 5854 1411	fax: +86 21-5854 1417	sales@moog.com.cn
Finland	tel: +358 9 2517 2730	fax: +358 9 2517 2739	sales.finland@moog.com
France	tel: +33 (0)1 45 60 70 00	fax: +33 (0)1 45 60 70 01	sales.france@moog.com
Germany	tel: +49 07031-622-0	fax: +49 07031-622-100	Sales@Moog.de
India	tel: +91 80 2668 9947	fax: +91 80 2668 9963	sales.india@moog.com
Ireland	tel: +353 21 4519000	fax: +353 21 4519001	sales.ireland@moog.com
Italy	tel: +39 0332 421111	fax: +39 0332 429233	sales.italy@moog.com
Japan	tel: +81 463 55 3615	fax: +81 463 54 4709	sales@moog.co.jp
Korea	tel: +82 031 764 6711	fax: +82 031 764 0929	sales@moogkorea.co.kr
Luxembourg	tel: +352 40 46 40-1	fax: +352 40 46 40 909	sales.luxembourg@moog.com
Norway	tel: +47 22 43 29 27	fax: +47 22 43 29 01	contact@moog.no
Russia	tel: +007 83171 31811	fax: +007 83171 31813	sales.russia@moog.com
Singapore	tel: +65 6773 6238	fax: +65 6777 7627	sales@moog.com.sg
South Africa	tel: +27 11 655 7030	fax: +27 11 655 7131	southafrica@moog.de
Spain	tel: +34 902 133 240	fax: +34 902 133 180	ventas@moog.es
Sweden	tel: +46 31 680060	fax: +46 31 287532	contact@moog.se
United Kingdom	tel: +44 1684 296600	fax: +44 1684 296760	sales@moog.co.uk
USA	tel: +1 716 652 2000	fax: +1 716 687 7910	sales.icd@moog.com

MOOG

Moog Inc., Industrial Controls
USA: +1-716-652-2000
Germany: +49-7031-622-0
Japan: +81-463-55-3615
For the location nearest you, contact www.moog.com/worldwide.