DELTA COMPUTER SYSTEMS

Closed-Loop Motion Control Simplifies Non-Destructive Testing

Repetitive non-destructive testing (NDT) applications abound, and designers should consider using programmable motion controllers to power flexible testing scenarios. Fluid power should be considered where a predictable amount of force must be exerted, where the compressibility of the fluid medium can be used to avoid damage to the device under test, or where heavy loads must be held or moved as part of the testing process. Electric servos can also be used to power test axes if force can be controlled.

Simulated reality

Motion actuators can be driven to simulate real-world conditions, such as applying force to aircraft landing gear to simulate the loads that the gear would encounter in an actual runway landing situation. Similarly, the hydraulic actuator in a building truss tester can apply loads to simulate harsh environmental conditions such as wind and snow loading. In these applications as well as others such as a vehicle leaf spring tester, and a tester of medical prostheses, motion actuators can apply the same usage patterns over a period of days or weeks that the items under test would normally encounter over a lifetime.

Closed-loop control of position and force makes it possible

Gaining the full potential from motion sources in testing applications requires the use of an electronic motion controller implementing closed-loop control of the pressure or force being applied to the device under test in addition to precise position and/or speed control. Simply controlling the position of an actuator is not adequate because it is not possible to detect subtle changes in the physical properties of the subject device unless the force required to move or flex the device can be monitored closely. In a fluid power system, the force being applied by an actuator can be obtained by monitoring the difference between pressures on either side of the piston. In a mechanical motion system, force can be measured with a load cell.

All the right connections

Figure 1 shows a diagram of a hydraulic leaf spring tester. The tester is designed to flex the spring repetitively while measuring the force required to displace the spring leaves. The motion controller connects to pressure sensors for measuring force and to a magnetostrictive linear displacement transducer (MLDT) for determining the position of the actuator. In a typical test operation, such as the leaf spring tester shown in Figure 1, position control may be used to put the actuator in approximately the right position for applying a controlled amount of force. An electronic motion controller such as one of the RMC family of Motion Controllers (RMC70 Series or RMC100 Series) from Delta Computer Systems, Inc. (Vancouver, WA) can smoothly transition between controlling position to controlling pressure/force.

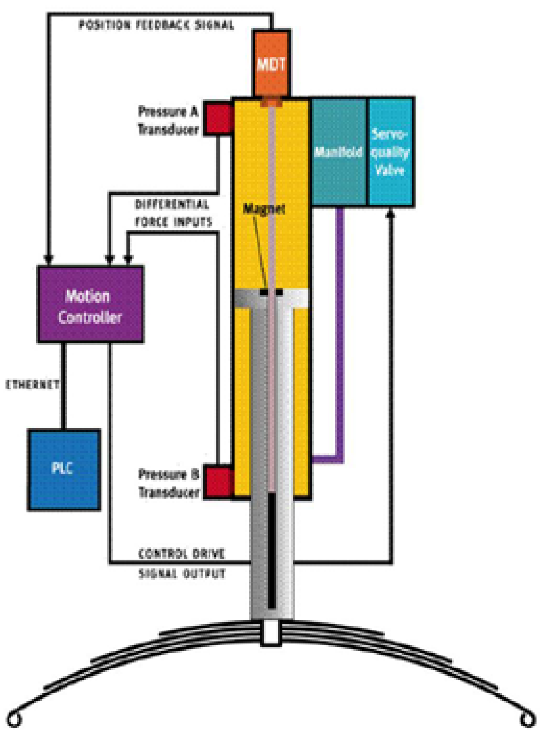

Figure 1. Hydraulic leaf spring tester controls both position and force being exterted by the actuator.

The motion controller drives the hydraulic cylinder by sending analog signals to a proportional servo valve that is capable of making precise adjustments (sinusoidal, or other waveforms) to cylinder pressure to control the hydraulic actuator's force or positioning. A hydraulic fluid accumulator is provided (not shown in Figure 1) to store hydraulic pressure, ensuring that consistent hydraulic system supply pressure is available to operate the servo valve during spring compression cycles.

Programming the motion

As mentioned, NDT programs often involve the application of repetitive stress cycles on the device being tested. A motion controller that supports direct execution of repetitive motion operations makes it quick and easy to set up testing profiles. For example, Delta Computer Systems' controllers can produce precisely repetitive motion sequences such as trapezoidal profiles, ramp up/down profiles, and sine waves (see Figures 2a and 2b).

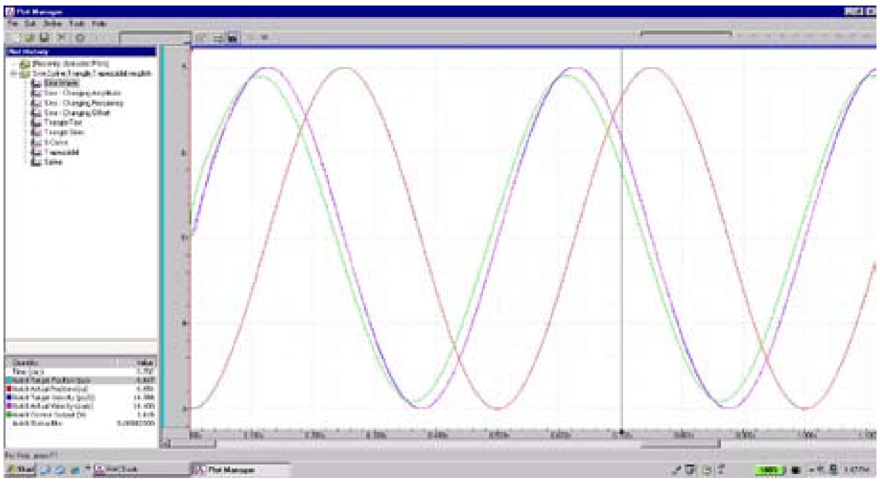

Figure 2a. A plot of continuous sinusoidal motion produced by an RMC150 motion controller. The red curve plots axis position versus time and the violet curve plots velocity versus time. As this system is tuned precisely, the actual and target position and velocity curves overlap.

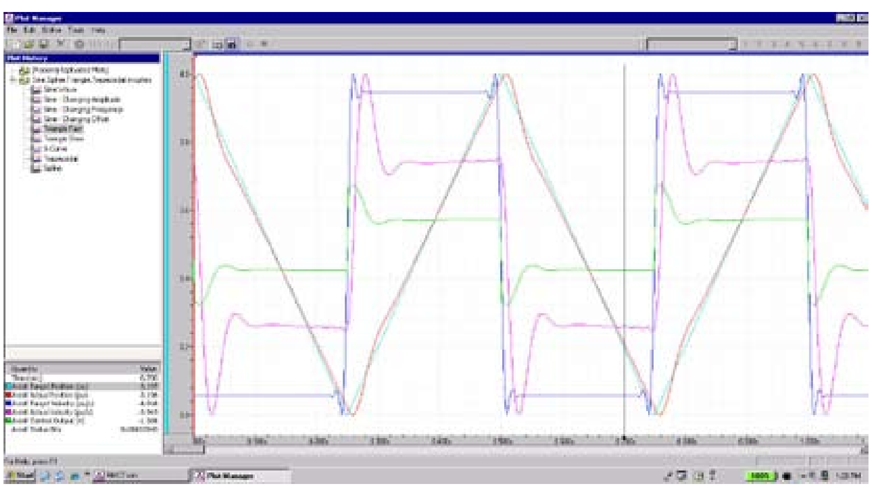

Figure 2b. A plot of continuous ramping up and down motion produced by an RMC150 motion controller. This system is not as precisely tuned as that of figure 2a, as the target and actual position and velocity curves do not precisely match.

Delta controllers can also generate complex, repetitive profiles using spline functions.

Interfaces to industry standard test environments

Another factor that contributes to building a good platform for non-destructive testing applications is the ability to interface with popular data acquisition and control software programs that are hosted on PCs, such as National Instruments' Labview or Microsoft Visual Basic or Visual C++. Delta Computer Systems' RMCLink software component enables direct access from Windows-based PCs running data acquisition software to the motion controller (See Figure 3). RMCLink enables the PC application to read and write registers in the motion controller and issue commands. Direct connection occurs via serial port or Ethernet access.

Figure 3. RMCLink from Delta Computer Systems, Inc. enables PCs running popular testing software to gather testing information directly from Delta's motion controllers.

The RMCLink software product includes fully-functioning example projects (embedded in the free software download) for many programming languages. These examples are ready-to-use and illustrate concepts such as reading positions, issuing commands, and reading plots.

Application Example: Electronic control delivers new capabilities for a leaf spring tester

When a systems approach is taken in developing the test system, new capabilities are enabled, such as the ability for outside control modules to interrogate the system and analyze process data. For example, leaf spring manufacturer Rockwell American of Seagoville, TX , used data on the force being applied to springs under test to identify how structural parameters in the steel change over time.

In Rockwell American's spring tester (Figure 1), the Delta Computer Systems RMC100 controller accurately follows an operator selectable, internally-generated target force profiles using an HMI. Each spring movement is controlled by continually adjusting drive output to the hydraulic valve 1000 times a second. Simultaneously, the minimum and maximum spring deflections are being monitored in real time during the force cycling and compared against allowable limits in order to determine any change in the properties of the spring. For each spring tested, these limits are found when the motion controller is commanded to enter force control (initiated by operator with the HMI's touch screen). At the beginning of the testing cycle, the system compresses the spring to minimum and maximum force set points while recording and storing the corresponding minimum and maximum spring deflections. This capability was very useful in helping Rockwell American diagnose and document a recent raw material quality problem. Another significant savings was in setup time when shifting from spring type to spring type.

If the position of the hydraulic actuator were to exceed operator specified tolerances during the continuous force control cycle testing, the spring properties may be changing, the spring may be ready to break, or one leaf in the spring may have already broken. If this condition happens, the RMC motion controller's continuous monitoring of position tolerances during force cycling will lead to an automatic system shut down. Because of these controls, the machine can run continuously with a minimum of supervision. The new machine is also capable of capturing and plotting test data for post-test diagnostics and record-keeping.

Application Example: Prosthetics tester leverages repetitive motion profiles and force/position control

A prosthetics manufacturer has the requirement, imposed by the International Standards Organization (ISO), for testing elastic ankle joints to insure that they can flex under realistic conditions through at least two million cycles. Key to insuring that they are tested realistically is to make sure that, during each cycle, the displacement of the joint is within a certain limit when a particular force is applied.

The tester uses two pneumatic cylinders, controlled by a Delta RMC75 2-axis motion controller. One cylinder is positioned to press on the heel and one to push on the toe of an artificial foot (see Figure 4). A load cell affixed to each cylinder measures the force being applied, while a magnetostrictive linear displacement transducer (MLDT) affixed to each piston measures the position of each actuator. As the test system cycles, the cylinders alternate their motion to flex the joint. Each cycle, the motion controller increases the force being applied on each cylinder until it reaches a predetermined setpoint and then measures the amount of deflection of the joint to insure that it is less than the maximum allowable.

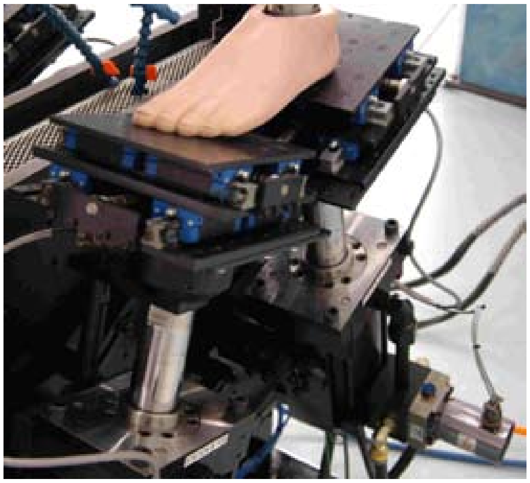

Figure 4. A pneumatic prosthetic foot tester, showing one cylinder pressing on the toe and one the heel of an artificial foot.

Because data on the amount of deflection is collected every cycle (by a PLC that reads registers in the motion controller), the tester can measure the onset of fatigue before a catastrophic failure occurs. The Delta motion controller has the performance to cycle the tester between two and three times per second – a rate approximately twice that of the previous controller used by the prosthetics company – doubling the throughput of the testing facility.

Pneumatics was chosen for this tester rather than hydraulics in order to keep the weight of the test system as low as possible, but since air is more compressible than oil, tuning of the system became a challenge. The real-time motion plotting and tuning tools that are provided with the Delta controller made tuning the system for optimal performance easier.

Application Example: Race car suspension tester makes eight axes move simultaneously to simulate real road racing conditions

A new eight-axis Delta RMC151 motion controller is being used in an advanced diagnostic testing system that provides racing teams with detailed data about the chassis and suspension of their cars in a variety of simulation scenarios. The system (Figure 5) provides precise suspension motion while measuring bump steer, camber change, and wheel loading, allowing suspension component interference checking throughout the suspension travel range. Data gathered enables the suspension of a vehicle to be completely characterized and tuned for optimal performance while on the simulator.

Figure 5. Vehicle suspension test system.

The RMC150 can be programmed to control both force and position on all eight motion axes simultaneously, and can synchronize or "gear" the motion of slave axes to the motion of master axes, enabling performance of the system to be scaled, while maintaining the relationships between the axes, without requiring reprogramming of the motion. The RMC150's RMCTools software supports graphing of motion profiles and automated tuning tools to speed the optimization of test profiles.

Conclusion:

Electronic motion controllers excel at moving multiple hydraulic or pneumatic axes and controlling force and position to generate real-world testing scenarios. Designers should look for motion controllers that provide precise closed-loop control and are supported with instruction sets, development tools, and interfaces that simplify the programming and tuning of testing profiles.

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