A SECRET WEAPON FOR ROOF-CRUSH testing

The CAPE roof crush test rig operates with hydraulics cylinders at each corner of a pressure plate.

Before you crush that bus or racecar chassis, find out how engineers at CAPE are optimizing test-rig performance.

by Bruce Coons

Evaluating how school buses and other commercial vehicles perform in crash-test scenarios is regular practice at the **Center for Advanced Product Evaluation** (CAPE) in Westfield, Indiana. The center, a unit of advanced vehicular safety systems manufacturer **IMMI**, designs and builds test rigs that help engineers determine whether there is survivable space inside the vehicle, and whether the vehicle's body-to-frame mounting system is sufficiently strong to withstand a rollover incident.

The tests performed at CAPE are typically designed to prove that vehicle manufacturing processes comply with standards set by organizations such as **SAE International** and the **National Fire Protection Association** (NFPA).

CAPE's engineering team recently completed development of a test rig that can provide vehicle OEMs with roof crush testing up to 100 tons (890 kN). The unit can also be used to test off-road vehicle roll cages and racecar chassis. The rig uses four hydraulic actuators (cylinders), mounted at the four corners of a heavy-gauge pressure plate and controlled as four separate motion axes.

At the core of the new test system is an eight-axis RMC150 electro-hydraulic motion controller manufactured by **Delta Computer Systems**. CAPE engineers had previously integrated Delta motion controllers into two other test rigs before the new roof crush system was developed. According to the facility's Technical Director, Ryan Hoover, the RMCs exhibit superior stability for test applications. He described the Delta software as "very professionally developed and finished," noting that CAPE had previously experienced control software that was often "buggy."

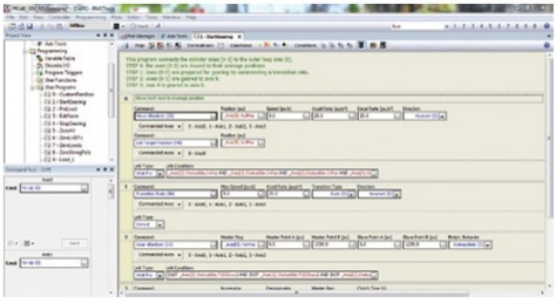
"Virtual Gearing"

CAPE engineers used a special function of the RMC151 motion controller called "Virtual Gearing" to cause all four axes to move in precise synchrony, to ensure that the pressure plate is kept completely level during a compression operation. The four "slave" axes follow a virtual "master" axis, which is set up to control the position of the pressure plate and the cumulative force being applied.

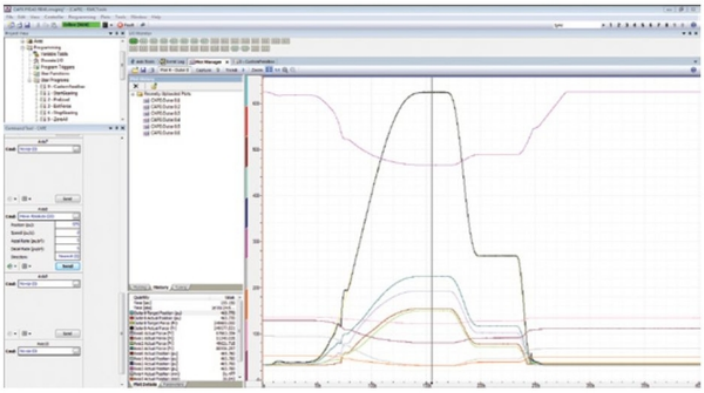
The motion controller tracks the position of each corner cylinder using inputs from a linear variable displacement

IMMI

Delta Computer Systems' RMC150 can control up to eight motion axes simultaneously, while serving as a data acquisition subsystem in test applications. A built-in Ethernet interface is provided for uploading test data from registers inside the controller.



The RMCTools software can be used for both developing motion programs and setting up/ monitoring tests in process.



RMCTools Plot Manager enables the test operator to visually track the values of all transducers and the values of the geared axis parameters during a test.

transducer (LVDT) attached to the cylinder. It controls the compression force using a load cell mounted on each cylinder rod end.

Besides the motion axes, the Delta controller gathers information on the deflection of the vehicle under test by tracking four "reference axis" inputs which are connected to string potentiometers mounted to the body and test frame. In this way, the RMC functions as a multi-channel data acquisition device in addition to a motion controller.

The typical compression cycle starts as follows. The hydraulic pump is turned on and the transducers are initialized to zero values. Then the four compression cylinders are set up to be geared together, and the system is given a command to move the steel pressure plate up and out of the way. The vehicle cab/body is placed in the rig, and the pressure plate is lowered until it reaches a position that is just above the cab but not touching it. The command is then given to pre-load the rig to 500 lb (227 kg), followed by the command to apply the full load, a process that takes between one and five minutes.

The system is allowed to rest under load for 30 seconds and then it is unloaded to zero pounds on the load cells. Finally, the press plate is moved completely off the cab, and the test data is downloaded from the motion controller to the network drive over the RMC's Ethernet interface.

Programming the motion steps was done using RMCTools software, provided free with Delta's motion controllers. It enables programming the controllers using high-level commands, such as the Virtual Gearing arrangement. As the accompanying screen shot shows, programming the operation of the four corner cylinders is done by filling in boxes and selecting options from pull-down menus. Velocity, acceleration and deceleration rates can be set to cause the axes to start, stop and move smoothly.

The RMC hydraulic systems use proportional servo valves to enable precise control over the closed-loop motion parameters.

Following programming, the system needed to be tuned. "Initially, the test rig was shaking," said Hoover. "Then we used Delta's Tuning Wizard, another part of RMCTools, to get the system pretty close to where we wanted it to be." After that, the CAPE team did fine-tuning, operating the press plate up and down at various speeds.

"We validated the tuning process by testing different cabs with different amounts of crushing force," Hoover explained.

A test operator interface

During testing operations, the Delta motion controller in the CAPE test rig performs the data acquisition and maintains all the test data internally. Not just for motion program development; the RMCTools software can handle test system operator interface functions and data transfer to an attached PC. The package is capable of developing and running an array of tests, Hoover said.

An accompanying graph shows how the various test parameters can be tracked and displayed in real time. The black plot line is the total force being applied, and the upper magenta line shows that some roof crushing has occurred. The relationship between crushing force and amount of crush at all points in time is clear, and the plot serves as documentation of the complete test cycle.

Serving as "a powerful core of a flexible electrohydraulic test system, Delta controllers are easy to program and tune for engineers," Hoover noted. ■

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