

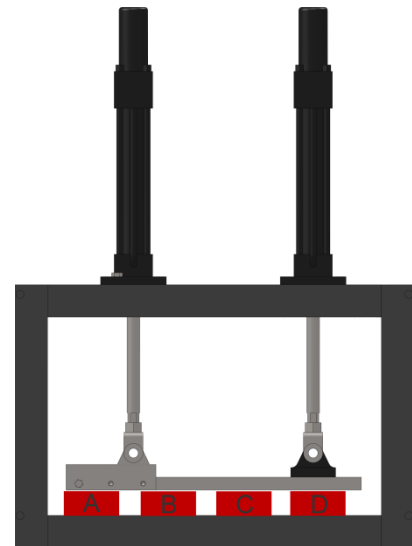
Synchronized Position-Force Control

Using cascaded loops

For multi-axis presses, from 2 axes to 24 axes

The RMC1 motion controller from Delta Computers Systems, Inc. offers control of the total resultant force of multiple independent rams while maintaining equal positions of all the rams, regardless of the load distribution. Many presses provide this synchronization via mechanically linking the rams together with very heavy guides and platens such that the rams cannot physically become skewed. Electronic synchronization of the rams reduces the need for such heavy construction.

For example, this 2-axis press controls the total applied force while keeping the rams level, regardless of whether the load is at location A, B, C, or D:



Required Equipment

Position Feedback

For best results, high-resolution position feedback is required. The preferred option is magnetostrictive transducers with SSI output, resolution of 1 μm , mounted inside the cylinder.

Force Feedback

The force feedback is typically comprised of two pressure sensors per ram which the RMC employs to calculate the total force of each ram. The response time of the sensors must be 1 msec or less. Alternatively, one load cell per ram may be used to measure the total force. Load cells provide a more accurate measurement than pressure sensors because pressure sensors cannot account for the cylinder friction. Load cells present a greater challenge in mounting and wiring.

Number of Axes

The RMC200 supports up to 24 axes of synchronized position-force control.

The RMC151E supports up to 6 axes of synchronized position-force control if SSI position sensors are used.

The RMC75E also supports synchronized position-force control for two cylinders. However, notice that after adding the two position-force axes, RMCTools claims an additional outer-loop axis cannot be added. If the outer-loop axis is added first, then RMCTools allows the two position-force axes.

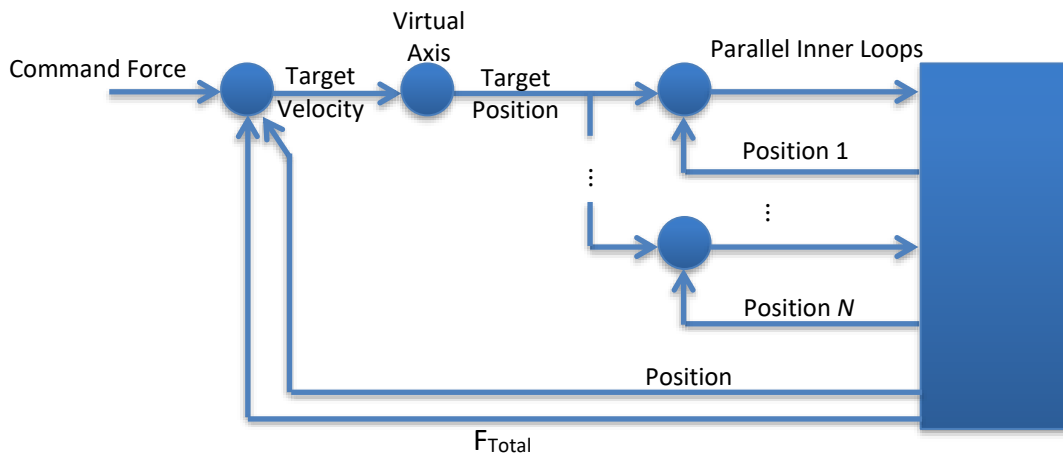
Control Methodology

The synchronized position-force control uses a cascaded loop architecture, as illustrated below. The individual cylinders are parallel inner position control loops. Since they receive the same target position from the outer loop, they will always be commanded to be at identical positions.

The outer loop is a position-force axis. The feedback for this outer loop is obtained using custom feedback. The force feedback is the sum of all the forces of the individual cylinders. The position feedback is the target positions of the inner loop.

For best results, the output of the outer loop should be considered to be proportional to the velocity. However, the inner loops need a position command, not velocity. Therefore, a virtual axis is geared to the output of the outer loop, then the inner loops are geared to the position of the virtual axis.

Once the axes are set up, and the gearing is connected, the outer loop will operate as a typical position-force axis while the cylinders are all at identical positions.



Setup Procedure

1. Define each cylinder as a position-force axis with differential pressure inputs.
2. Create a Cascading Outer Loop axis as position-force, using custom feedback for the position, and custom feedback for the force.

3. Create a virtual reference axis.
4. Make a single-step user program that does the following:
 - a. Calculates the sum of forces of the cylinders and assigns it to the outer loop axis' SecCustomCounts register.
 - b. Assigns the outer loop axis' CustomCounts register to be the average positions of the cylinder positions.
 - c. Optionally, add a calculation of the difference of the cylinders' actual positions and save it in a variable. This can then be plotted to monitor the skew.
5. Set up and tune the cylinder axes.
6. Set the travel limits of the virtual axis to be the same as the cylinder axes.
7. Set the travel limits of the outer loop axis to be the same as the cylinder axes. The Scale and Offset should be 1 and 0, respectively.
8. To connect the outer and inner loops together, make a user program that does the following:
 - a. Sets the Target Position of the virtual axis to the average positions of the cylinders, which is the same value as the outer loop's actual position.
 - b. Moves the cylinders to their average position.
 - c. Sends a Gear Absolute command to each axis to gear it to the position of the virtual axis. It will need to use the Transition Rate also.
 - d. Sends a Gear Velocity command to the virtual axis to gear it to the Control Output of the outer loop axis. The ratio is recommended to be 1 or less.
9. Now the outer loop axis can be tuned.

If the feedback is noisy, a filter can be implemented. Delta's example project includes a user function to implement a filter and is used in the custom feedback user program.