On a Roll with Caster Quality

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Category:
Prototype/Validation Test

Products Used:
NI LabVIEW 8.5
NI Motion 7.6.0.3
NI FieldPoint 6.0
NI cFP-1808
NI cFP-304
NI cFP-401
NI PCI-7342

The Challenge:
Develop a software application to evaluate the durability of caster wheel-sets. The application has to monitor as many as twelve individual tests while controlling a motorized dial plate. In addition, to maximum system reliability and reproducibility of results, the system must be reconfigurable to track test changes.

The Solution:
Leveraging modular LabVIEW-based software architecture, Data Science Automation (DSA) has created a system utilizing Compact FieldPoint units to monitor and control over fifty digital input and output channels. Additionally, a NI-7342 motion card provided reliable motion profiles control of the test system itself.

Abstract:
An equipment manufacturer was at the mercy of an outside supplier for the casters supporting their products. To cut cost while continuing to produce high quality products, they needed to bring caster design and testing in-house. This new effort required an efficient, easy to use, standalone mechanical test stand to support the evaluation of new caster designs. The test stand consists of 12 individual test fixtures controlled through Compact FieldPoint modules while a NI-7342 motion card manages the operation of a rotation dial plate that exercises the casters being tested.

Overview
Few people give caster wheel assemblies a second thought – that is of course until the wheel on their cart don't work. Recognizing the vital niche that casters fill in a product's overall functionality, a commercial products manufacture recently began reevaluating their policy of purchasing these important components from outside vendors. What they saw was that this out-sourcing resulted in high production costs and low quality. The obvious solution was to bring the design and production of the casters in-house.

However, this new effort had its costs as well. For example, it required the creation of a system to perform life-cycle testing of candidate caster designs – a requirement that Data Science Automation (DSA) was called-in to fulfill. The result is a machine with the capacity to simultaneously test 12 casters. To meet the customer's obvious desire to maximize the return on their investment in test hardware, each caster station needed to be configured individually. In addition, the test plate on which the casters under test ran was designed to support a variety of motion profiles.

The Nuts and Bolts

The mechanical design for this project utilizes 12 individually-controlled vertical solenoids with proximity sensors. This instrumentation allows the system to measure each caster's reactions and retract casters that fail mechanically. The designs also incorporate four individually-controlled horizontal solenoids to jog each caster axially, ensuring a smooth turn when the table reverses direction. The 53' dial plate top on which the casters ride, revolves at a rate between 15- and 60-rpm, providing testing speeds between 1 and 10 mph. For safety, the design includes three emergency stop door hinge sensors (with an electronic bypass) and a non-bypassable operator emergency stop.

To control this hardware, the system teams Compact FieldPoint hardware with LabVIEW 8.5. The NI-7342 series motion card was selected for this project due to its ability to manipulate and blend multiple motion profiles. DSA selected the NI-cFP 401 and NI-cFP 304 modules for their ability to produce and receive 24-volt signals in the required frequency range.

Finally, DSA designed the application's operator interface to remove the need for a keyboard and mouse – substituting instead a touch panel. Figure 1 shows how the application at the start of a new experiment. The user interface represents the current state of the casters using color. In the figure, the dark green color represents casters that are turned off. Next, red identifies the caster that has failed during prior testing. Yellow flags a caster that the operator has retracted and won't be tested.

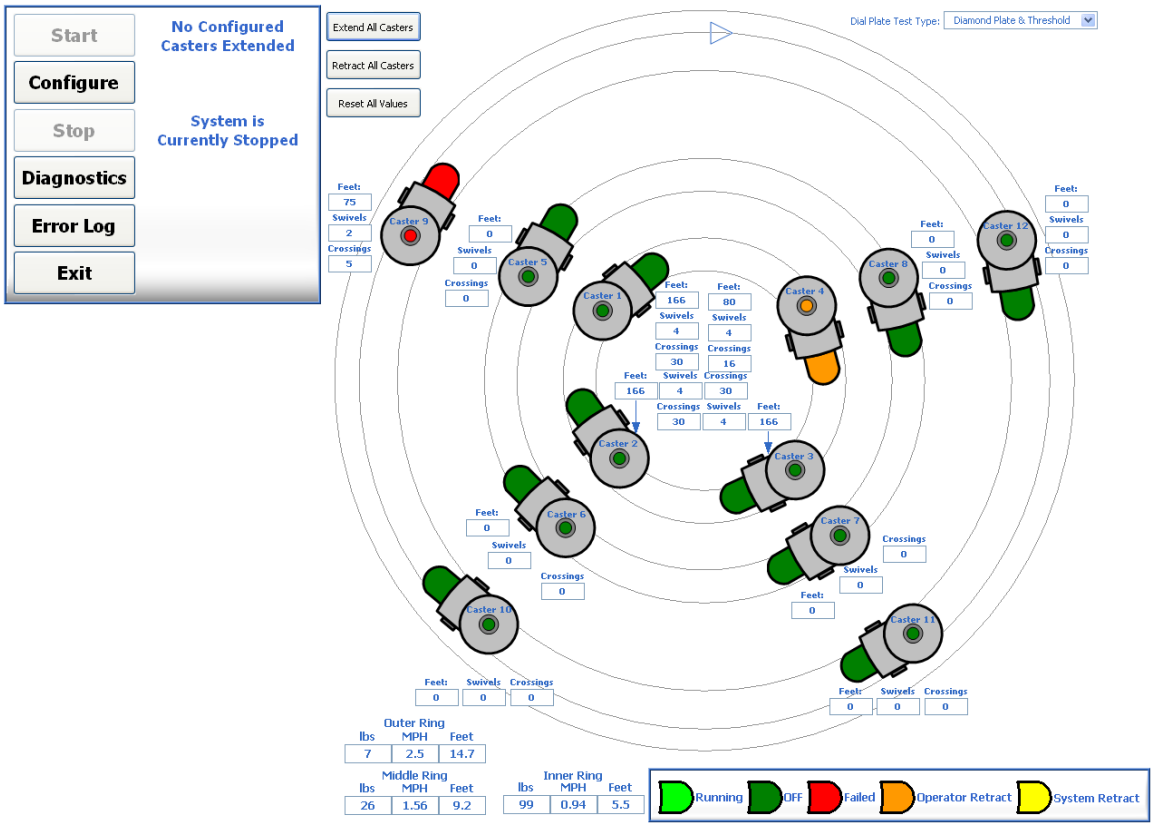

Figure 1 – Color coding in the user interface allows the operator to see at a glance the status of the casters currently under test.

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Note that because the system utilizes a touch panel in the place of a keyboard and mouse, DSA had to create on-screen emulations of a keyboard and numeric keypad. Utilizing LabVIEW events, the code presents these controls automatically when the user selects a numeric or string control. (Figure 2)

Figure 2 – Due to the operating environment for the system, a traditional keyboard was impractical. Therefore the system utilizes these pop-up on-screen representations to allow the entry of text or numbers.

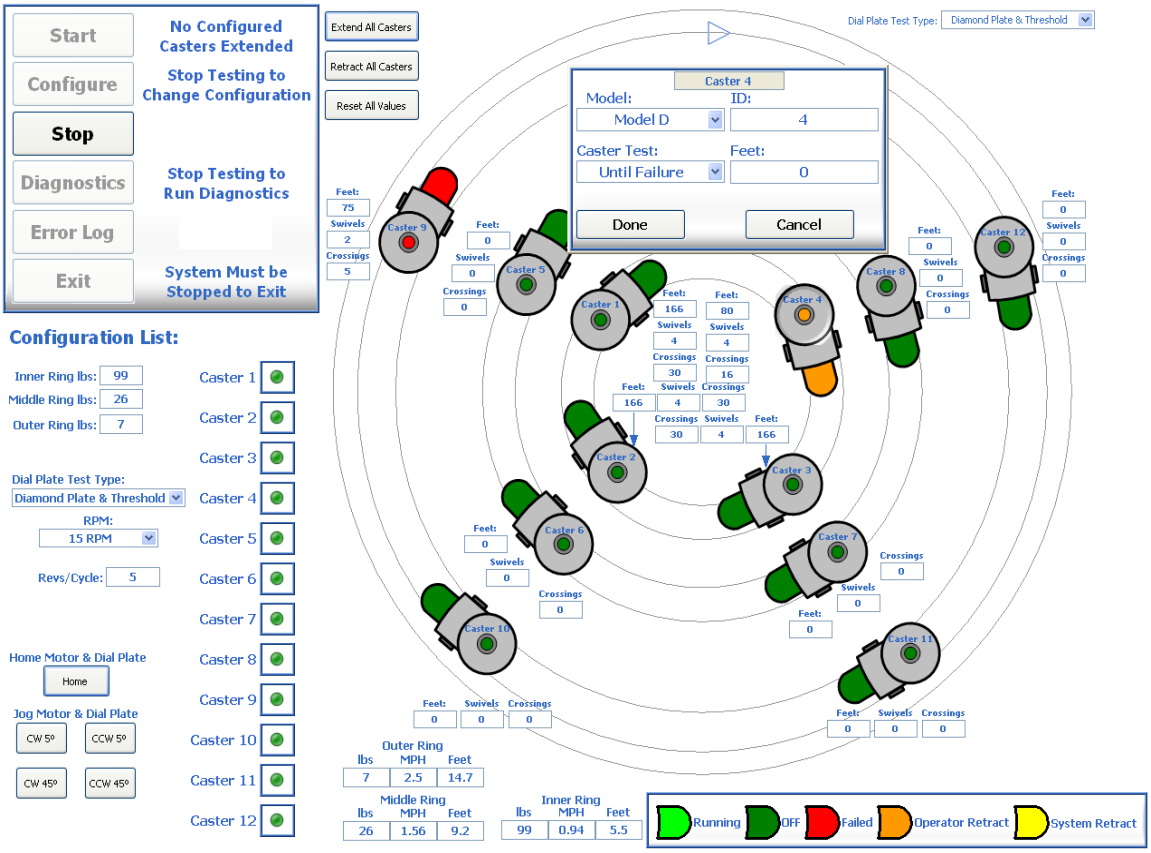

Figure 3 – The test status screen also provides the basis for entering the data required to define a test or experiment that needs to be run.

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Configuration & Data logging
To configure a test run the user interface provides controls (Figure 3) for entering test details including the force that will the system will apply to each ring caster during the test, the dial plate's travel speeds, number of cycles between rotation, type of experiment, and individual caster test states.

In terms of data collection, the system automatically collects a list of user-defined data values for each caster, throughout the run. The system stores this data to either a customer-supplied database, or a series of standard text files.

Motion
During normal operation the system turns the dial plate an operator-specified number of times clockwise followed by an equal number of turns in the reverse direction. The number of revolutions is specified in the test configuration. At the same time this process is going on, the system is also varying the dial plate's speed profile as defined in the test setup. Preset speeds are 15-, 30-, and 60-rpm

The system is programmed so that once a test sequence is started no further operator interaction is required. For example, the application logic automatically deals with caster failures. When a failure is detected the system executes a motion profile for a "clearing routine" that causes all engaged casters to retract and the plate to revolve uninterrupted for 5 complete revolutions of the plate and stopping. After this interruption, the logic resumes the programmed motion profile and test sequence from where it was interrupted and finishes the test.

Digital Control
Each caster under test is attached to one of 12 caster testing units. Each unit incorporates solenoids for vertically extending or retracting a caster. To control the machine's vertical and horizontal movement, the system uses 24-volts digital signals to extend or retract the casters. To verify command completion and determine caster experiment states, the system reads 24-volt digital feedback signals. The height the caster holds the test unit above the table is monitored to indicate failure. If the part fails to support the applied force, the caster is determined to have failed and is retracted for further analysis.

The Bottom Line
The result finished system described in this paper met the customer's need for reliable design testing, which in turn supports their broader goal of lower cost and improved product quality for their customers.

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