Case Study:

The need for speed driven by ABB: motor drives critical to improve speed, precision and control in engine-performance testing tool used by NASCAR teams

(Spintron™ test machines evaluate hundreds of variables to enhance engine development)

Spintron™ is a unique test-bench machine that provides valuable information to help maximize engine performance. Used extensively by NASCAR teams, it runs durability tests, component failure analyses and frictional horsepower checks on valvetrain and bolt-on engine components.

Outfitted with lasers and high-speed video cameras, the Spintron precisely measures, identifies, and records crucial characteristics of the valvetrain, such as valve bounce, lofting, spring harmonics and pushrod deflection. Spintron provides instantaneous results on-screen, plus comprehensive reports that can be printed immediately or stored for later analysis.

In addition to its popularity in the NASCAR industry, Spintron is gaining share of mind and usage with Busch racing, IRL and Formula One teams. The machine also is used by OEMs for specialized testing of engine parts.

Spintron is a joint venture between CIM SYSTEMS INC. (Noblesville, Ind.), an ABB Robotics integrator, and Trend Performance, Inc. (Warren, Mich.). Trend Performance manufactures the test-bench machines with design engineering and software provided by CIM SYSTEMS.

To provide the speed, torque performance and precision control needed to ensure accurate testing, the Spintron’s electric motor is controlled by an ABB ACS800 drive with Direct Torque Control (DTC). DTC offers accurate, repeatable torque control with rapid response to changes in load and speed to provide true representation of real-time road and track conditions.

Dave Fox, president of CIM SYSTEMS, INC., developed Spintron in 1994, when his uncle, Bob Fox, owner of Trend Performance, Inc., asked him to develop a test stand for his pushrod manufacturing business. Fox searched for a testing device and, unable to find the exact product he was looking for, he, and Software Engineer David Lanham, decided to develop a product that could be marketed to others in the performance engine industry. With their combined experience in robotics, automation, engineering and programming, they developed the Spintron.

Machine Enables Comprehensive Testing of Engine Components

The Spintron’s three main testing functions include:

-- Valvetrain development with Laser Valve Tracking System – graphically identifies, documents and records crucial characteristics of the valve train, such as valve bounce, lofting, spring harmonics and component deflection.
-- Step testing – Allows the technician to test bolt-on components or a complete valve train at various speeds. Through preset RPM values, the Spintron spins the engine at each RPM entered in the set-up screen. It records and graphs data from a variety of sensors at each speed, then moves on to the next rpm setpoint.

-- Cycle testing – simulates a limitless number of race or street miles to test one component, a set of components or to test parts against each other. Spintron software provides the RPMs usually experienced at a given race track during typical conditions at or beyond normal engine speed without the risk of expensive engine failure.

“The Spintron uses an electric motor to rotate an engine, similar in concept to a dynamometer (dyno), except it runs in reverse,” Fox explains. “Instead of the engine running and using the dyno to put a load on the engine, we spin the engine with the electric motor, and then do more of an isolated testing procedure with it. So, the electric motor spins the Spintron spindle, which drives a dummy crankshaft, and that spins the valve train. We call this ‘motoring’ in the industry.”

The electric motor is controlled by an ABB ACS800 50-250 HP drive. The drive receives commands from the computer via Profibus or direct fiber optic link, and adjusts the speed and torque to the motor to control speed and acceleration. DTC monitors and adjusts, as needed, the AC motor torque approximately 40,000 times per second. This ensures accuracy and enables the dynamics of the load to be applied to the test stand.

**ABB Drive Provides Rapid Response to Computer Commands**

The Spintron was outfitted with the ACS800 when the machine’s previous drive could not communicate with the computer program at a rate fast enough to satisfy testing specifications. “When we first developed this in 1994, there weren’t a lot of companies that made drives that communicated with the computer at a high rate of speed,” Fox says. “Most were designed to follow an analog signal, requiring a programmable controller or some device outputting a 0-10 volt signal. Then, the drive would use that reference to adjust its speed. We definitely wanted the capability to talk directly to the drive through a communications port.

“Also, our previous drive would struggle if we attempted to make a ramp and RPM change in less than one second, so we started looking for a drive that would provide faster, and more accurate response. That’s when we found that ABB had a drive that would meet our specifications,” Fox adds.

The ABB ACS800 accurately simulates real-time conditions – as real as they get in a NASCAR Nextel Cup race, according to Terrell Ebright, sales engineer, Ronald Ray & Associates, Inc., (Indianapolis), an ABB manufacturer’s representative. “The load torque can be varied from zero to full torque within milliseconds, ensuring highly responsive changes to load torque and speed. The benefit is a more accurate picture of precisely how an engine will perform,” he says.

**Valve Train Testing Begins with a Baseline Trace**

The Spintron™ utilizes a data acquisition board to collect data relative to the engine’s rotational position. The process begins as the Spintron’s software sends the drive a ramp and speed reference. The motor spins the engine at a speed at which the valve train is stable (typically 2000-3000 RPM). A laser directed at the valve face measures the valve’s position and outputs an analog signal to the data acquisition board. Each time the engine rotates one degree, a spindle-mounted encoder generates a square-wave pulse, triggering the computer to record the valve’s position. The valve displacement is graphically displayed (lift/degree).

After the base line is collected and displayed, the engine speed is increased to the next preset RPM, and the Spintron records and graphs each new valve trace over the baseline trace to provide comparisons of valve train stability at various RPMs.
Cycle Testing Pushes Drive To Limit

Ebright explains the ABB drive is able to handle the high rate of speed changes needed to simulate a NASCAR race. With the ACS800, there is instantaneous response. ABB gets much better response for acceleration and de-acceleration than other drives on the market, because of the company’s exclusive Direct Torque Control (DTC) algorithm and flux braking (standard feature). This is a must for proper lap simulation testing.”

“We can collect and graph data across a predefined range of RPMs and then compare the results,” Fox says. “The problem with our old drive was the response time between RPM changes was sluggish and therefore did not provide an accurate representation of on-track RPM changes. With the ABB drive, we are able to send ramp and speed data to the drive ten times faster for better test resolution and accuracy.”

Fox explains. “From a communications standpoint, the ABB drive is significantly more solid than our previous drive. With our old drive, for example, when we told it to stop the test, we had to keep polling it to see if it actually did what we told it to. The serial communications, or the bus communications, weren’t the drive’s top priority, so sometimes it would miss commands that we sent to it, and sometimes it wouldn’t send commands back when we requested it. That required us to build redundancy into the software. With the ABB drive and Profibus communication, we don’t have to do that. It responds immediately.”

Another problem with simulating the RPMs of an engine is deceleration. When a driver enters a turn, they use the brakes to slow the car and engine. The Spintron relies on the drive system to absorb the energy created when reducing the RPM. The ABB drive utilizes flux braking to reduce the motor speed in a short period of time, and provides the highest possible braking torque without additional hardware costs and installation, such as external dynamic brake choppers and resistor banks.

Multiple Drives Working in Concert

The high-performance drive also allows Spintron to control multiple drives all connected to the same computer, allowing them to react in unison, Fox said. “If we want to have an oil pump match the engine speed, but at a gear ratio of 50%, we can do that with the ACS800. We can dynamically change that gear ratio with the software, and all the drives respond to it proportionally.”

This ability to control multiple drives led to the development of the latest Spintron oiling system which consists of two external dry sump pumps, each powered by an electric motor. One motor powers the oil pump stage while the other powers the scavenge stages. Each motor is controlled by a smaller ACS800 drive (lead/follower configuration) that tracks the main drive using fiber optic communication modules.

The oiling system drives have the ability to maintain a specified pressure or vacuum level by adjusting the motor RPM to accurately hold the preset value, utilizing the PID loop control of the drive. This becomes important when studying the amount of frictional horsepower an engine or bolt-on component consumes.

NTAC Module Offers Enhanced Feedback; Closed-loop Control

For enhanced feedback, CIM SYSTEMS also chose to add an NTAC-02 pulse encoder interface module to the ABB ACS800 AC drive. The plug-in module accepts a pulse input from the encoder for a feedback signal, a standard component in the dynamometer industry.

“The importance of the feedback is to give the user better control, referred to as closed-loop control,” explains Ebright. “For example, in a standard drive, if I send a signal to go from 1000 rpm to 1200 rpm, I can’t verify it is at 1200 rpm. It may jump to 1205, 1196, and 1203 before it hits 1200. With DTC plus encoder, the drive immediately sets to 1200 rpm. The feedback verifies the command and the encoder provides more precision.”
ABB engineers helped CIM SYSTEMS set up a custom parameter list to help the drive communicate more efficiently. “We had specific things that we wanted to transmit back and forth between the drive and our computer communication systems every cycle,” says Fox. “So, every time we would do a communication, we would send over a package of information and the drive would send back a corresponding package automatically. With the previous drives, that might have taken eight transactions to accomplish the same thing.”

Another option added is the DDCS card, which is a fiber optic communication card used with ABB’s DriveWindow™ software package. The DDCS board sits inside of the drive, and allows the user to communicate from a laptop. With DriveWindow, the entire drive parameter set can be saved to a PC with just a few clicks. It also can restore saved parameters back to the drive control board. DriveWindow uses a high-speed fiber optic cable network for communication between the drive and PC. A fiber optic network is very fast, safe and electrical noise immune.

**Spintron Finds a Niche with Engine Builders**

Spintron machines are widely used to develop OEM and custom engines for all types of performance applications in the United States, Europe and Australia. “All of the NASCAR and top NHRA teams that build their own engines have at least one machine” Fox says. “We also provide systems for developing motorcycle, boat, and other racing engines. “In addition, there are businesses that will conduct testing for an end customer, such as Competition Cams and CV Products.

“We annually participate in the Performance Racing Industry Show, which is a showcase for performance products. With the connections Trend had with performance part manufacturers and the high-end racing teams, it was easy to introduce and market Spintron,” Fox says. “Hendrick Motor Sports was our first sale and other NASCAR teams soon followed. So, instead of starting with small shops and working our way up, we were fortunate to start at the top.”

It is all the more essential to provide testing equipment that delivers the highest performance possible. “The equipment must earn its keep – now, and into the future,” said Fox and Ebright.
Used extensively by NASCAR teams, Spintron™ is a unique machine that runs durability tests, component analyses and frictional horsepower checks on valve-train and bolt-on engine components.

Hendrick Motor Sports, which conducts testing for racing teams, was the first company to purchase the Spintron. Virtually all NASCAR teams now own the machines.
Valve-train development with Laser Valve Tracking System on the Spintron precisely identifies, documents and records crucial characteristics of the valve train, such as valve bounce, lofting, spring harmonics and deflection.

Cycle testing on the Spintron machine simulates a limitless number of race or street miles to test one component, a set of components or to test parts against each other. Spintron software simulates the RPMs and accelerations experienced at a given race track during at or above normal engine speed without the risk of expensive piston, crankshaft or connecting rod failure.
The electric motor on the Spintron machine is controlled by an ABB ACS800 50-250 HP drive. The drive receives commands from a computer via Profibus, and adjusts the speed and torque to the motor to control speed and acceleration. DTC monitors and adjusts, as needed, the AC motor torque approximately 40,000 times per second.

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