Making the Most Out of Mechatronics

A design approach that links mechanical control and electric design helps machine builders to lower design and development costs.

As original equipment manufacturers (OEMs) continue to tap the benefits offered by today's advanced automation, they are looking for ways to more effectively link the mechanical and control worlds. One approach that continues to gain momentum is mechatronics – the combination of mechanical and electrical engineering. This article will summarise the concept of mechatronics and how machine builders can benefit from using it.

Defining Mechatronics

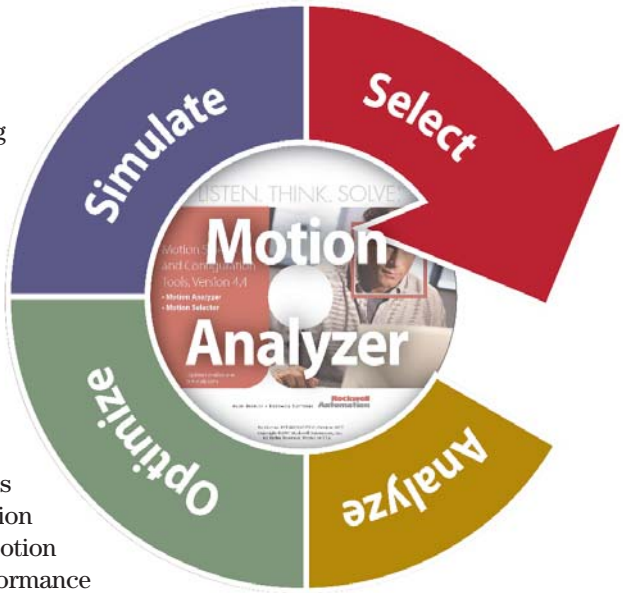
In traditional machine building, individual mechanical, control and electrical design teams work independently to produce separate pieces of the overall machine. To optimise the available mix of technologies, there needs to be a synergistic blend between the different engineering disciplines. This is precisely what mechatronics aims to deliver.

It is an interdisciplinary approach that allows machine builders to bring engineering processes closer together, improving communication and expanding the available knowledge base. Designers can more easily address configuration and integration issues up front in the product development cycle and minimise the chance of encountering problems in subsequent stages. The results of this concurrent engineering approach are lower design and development costs, expanded functionality and a more robust, balanced design.

In addition, development time is reduced through the use of automation tools. Software, for example, provides performance and simulation analysis that helps machine builders to select mechanical designs – along with the optimum controls and software – that will maximise machine performance.

Analysis Assistance

Motion Analyzer software from Rockwell Automation® helps OEMs evaluate design alternatives for robotic motion control applications. In addition to its sizing, selection, optimisation and simulation capabilities, Motion Analyzer software offers performance evaluation features including ratio, torque and tolerance analysis.



- **Ratio analysis** helps mechanical design engineers make a mechatronics selection of gearboxes, timing belts and ball screws. It provides an "at-a-glance" view of any necessary trade-offs and guides users to an optimised solution.
- **Torque analysis** shows where the torque produced by the motor is consumed. As design engineers generally focus on how to move the load, they may factor in transmission losses, but rarely cross-reference with load losses. Torque analysis solves this issue by providing rapid "what-if" analysis. If the majority of the torque is being used to move the load, the design is sound. If over 75 percent is being lost in the transmission, it's back to the drawing board.
- **Tolerance analysis** provides application data, such as move time, mass, losses and ambient temperature, to be plotted against "health parameters" for the system. The software provides the means to rapidly analyze the system's tolerance to changes and alerts the engineer to any marginal design issues.
- **Simulation analysis** helps OEMs determine machine performance criteria such as parts-per-minute, dynamic stability, accuracy and settling time, and it gives design engineers the most realistic prediction of system performance short of building a prototype. System simulation takes into account how a Logix controller, working in conjunction with Kinetix® integrated motion (consisting of servo drives, servomotors and actuators) will perform for particular load requirements. This approach helps reduce the risk associated with adopting new designs and speeds up the iterative discovery phase, decreasing design-to-ship time.

Simulation tools such as Motion Analyzer not only help reduce design time but also minimise errors that are typically corrected much later in the development process. More importantly, the excellent reliability, optimised performance and faster time to market that mechatronics affords means more satisfied customers – and a more favorable bottom line for machine builders. AT

How Solar Trackers Keep on Target

To build effective solar tracker equipment, OEMs need a reliable automation system.

Solar trackers orient photovoltaic panels, reflectors, lenses or other optical devices toward the sun. Since the sun's position in the sky changes with the seasons and the time of day, trackers are used to align the collection system to maximise energy production.

Several factors must be evaluated when determining the use of trackers: the type of solar technology, the amount of direct solar irradiation, feed-in tariffs in the region where the system is deployed, and the cost to install and maintain the trackers. In addition, original equipment manufacturers (OEMs) must consider the automation system that will drive the solar trackers.

Solar Tracker Basics

Applications like concentrated photovoltaic panels (CPV) or concentrated solar power (CSP) require a high degree of accuracy to achieve precise direction of sunlight at the focal point of the reflector or lens. Non-concentrating applications don't require tracking, but using a tracker can improve the total power produced by the system.

There are many types of solar trackers, of varying costs, sophistication and performance. The two basic categories of trackers are single-axis and dual-axis.

Single-axis solar trackers can either have a horizontal or a vertical axis. The horizontal type is used in tropical regions where the sun gets very high at noon, but the days are short. The vertical type is used in high latitudes where the sun does not get very high, but summer days can be very long. In concentrated solar power applications, single-axis trackers are used with parabolic and linear Fresnel mirror designs.

Dual-axis solar trackers have both a horizontal and a vertical axis; thus, they can track the sun's apparent motion virtually anywhere in the world. CSP applications using dual-axis tracking include solar power towers and dish (Stirling engine) systems. Dual-axis tracking is extremely important in solar tower applications due to the angle errors resulting from longer distances between the mirror and the central receiver located in the tower structure.

Many traditional solar PV applications employ two-axis trackers to position the solar panels perpendicular to the sun's rays. This maximises the total power output by keeping the panels in direct sunlight for the maximum number of hours per day.

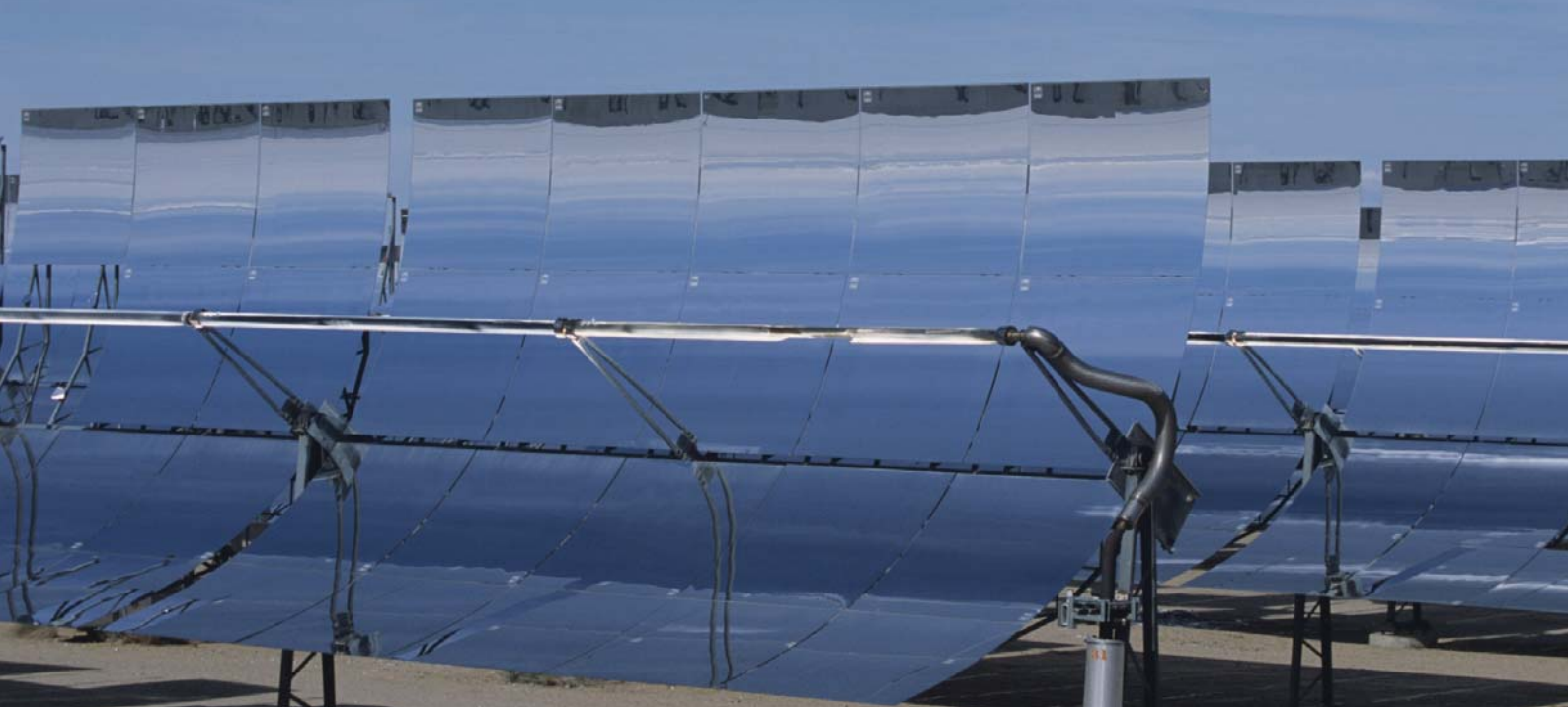
Key Components

The main elements of a tracking system include:

- **Sun tracking algorithm:** This calculates the solar azimuth and zenith angles of the sun, which are then used to position the solar panel or reflector to point toward the sun. Some algorithms are purely mathematical, based on astronomical references, while others utilise real-time light-intensity readings.
- **Control unit:** The control unit executes the sun tracking algorithm and coordinates the movement of the positioning system.
- **Positioning system:** The positioning system moves the panel or reflector to face the sun at the optimum angles. Some positioning systems are electrical and some are hydraulic. Electrical systems utilise encoders and variable frequency drives or linear actuators to monitor the current position of the panel and move to desired positions.
- **Drive mechanism/transmission:** The drive mechanisms include linear actuators, linear drives, hydraulic cylinders, swivel drives, worm gears, planetary gears and threaded spindles.
- **Sensing devices:** For trackers that use light intensity in the tracking algorithm, pyranometers are needed to read the light intensity. Ambient condition monitoring for pressure, temperature and humidity may also be needed to optimise efficiency and power output.

Tracker Control Algorithms

Tracker control algorithms typically incorporate a control strategy that is a hybrid between open-loop and closed-loop control. The open-loop component is needed because the sun can be obscured by clouds, eliminating or distorting the feedback signals. The closed-loop component is needed to



reduce the risk of errors that result from variability in installation, assembly, calibration and encoder mounting.

Closed-loop systems track the sun by relying on a set of lenses or sensors with a limited field of view, directed at the sun, and are fully illuminated by sunlight at all times. As the sun moves, it begins to shade one or more sensor. The system detects this and activates motors or actuators to move the device back into a position where all sensors are once again equally illuminated.

Open-loop systems track the sun without physically following the sun via sensors (although sensors may be used for calibration). These systems typically employ electronic logic, which controls device motors or actuators to follow the sun based on a mathematical formula.

The National Renewable Energy Laboratory (NREL) technical report (*NREL/TP-560-34302*, revised January 2008) provides information and code examples for a solar position algorithm in solar radiation applications. This report is a step-by-step procedure for implementing an algorithm to calculate the solar zenith and azimuth angles. Rockwell Automation® has utilised this report to build a standard logic template that can be implemented by OEMs developing tracker equipment.

Data specific to the location must be entered so the mathematical calculations are performed accurately. The values include the time zone, longitude, latitude, pressure, elevation, temperature, surface slope, surface azimuth rotation and delta T (difference between earth rotation time and terrestrial time).

Once the local parameters have been entered, the program will calculate the azimuth angle – used to determine the horizontal rotation – and zenith angles – used to determine the vertical tilt or elevation. OEMs can utilise their desired mechanics to position their trackers based on the calculated angles.

In Position

The Rockwell Automation control architecture for solar trackers is based on an Allen-Bradley® MicroLogix™ controller. The controller helps position the solar panels, mirrors, or lenses into the sun in order to capture the sun's energy.

The MicroLogix controller can be equipped with a positioning algorithm to mathematically solve the optimum tracker position for any time of the day. The outputs of the calculation are the zenith angle and the azimuth angle. Depending on the type of tracker being used (single- or dual-axis), one or both of these angles is then used to position the solar collection device.

The position loop can be closed in the controller or in the drive if the axis is so equipped. If the controller is used, the embedded High Speed Counter (HSC) instruction and corresponding inputs on the MicroLogix controller are utilised. Employing a drive that accepts an external encoder allows the position loop to be managed within the drive.

Since concentrated solar applications require more precise positioning to provide maximum and constant power generation, drives with positioning capabilities are often used. Some models in the Allen-Bradley PowerFlex® family of drives offer positioning features that can be coupled with an appropriate gearbox reduction ratio to manage and hold position.

In applications that require the installation of many trackers in a solar field, a central controller is often required to coordinate and monitor the trackers. Allen-Bradley ControlLogix® or CompactLogix™ programmable automation controllers fit the bill, opening the door to the capabilities of the Rockwell Automation Integrated Architecture™. The Integrated Architecture system brings together a multi-disciplined control engine, networking, a scalable visualisation platform and information technologies needed to develop efficient products.

A single or central controller can collect key operating conditions from each tracker in the field. What's more, data collected can be displayed in a SCADA system like FactoryTalk® View SE. Alarms and status information also can be displayed in a central location or accessed remotely.

Concentrated Power

By working with a trusted automation vendor like Rockwell Automation, OEMs can deploy technologies that can capture and convert solar energy efficiently and cost-effectively. With off-the-shelf components built to globally accepted standards, machine builders can offer end users rugged solutions that are competitively priced. And, OEMs can help end users reduce operating and maintenance costs through secure remote access and monitoring as well as troubleshooting. AT

Control System Powers Wind Turbines

The Rockwell Automation Integrated Architecture system helps manufacturer simultaneously control multiple turbines.

China's wind power industry is seeing unprecedented opportunities for development. With strong government support and abundant wind resources, experts forecast that China's wind power automation market will increase 30 percent to 50 percent in the next five years.

Shandong Changxing Wind Power Technology Co. Ltd., based in the northern province of Shandong on the country's eastern coast, is an industry leader in Chinese wind turbine production. This independent producer carries out in-house research and development, production and assembly of turbines as well as after-market support.

As the company began its production plan for building 850 kW wind power turbines, it teamed with system integrator Jinan Wenchuang. The team knew that they needed a control system able to integrate multiple segments including the variable pitch blade, yaw, variable flow, synchronisation, protection and monitoring.

An Open Platform

The rapid pace of development in China's wind power industry has given rise to a series of problems, including a dependency on overseas technologies for production. With two key parts – wind power main control systems and variable pitch blade control systems – the adoption of closed systems provided by professional wind power control manufacturers has led to high costs, blockage of key technologies and lack of technical service. These have created a bottleneck for further development in Chinese wind power enterprises.

To address these issues, Changxing needed to integrate a complex control system for both variable pitch blade control and turbine control. The company also needed to be able to service these turbines after they were built.

Changxing needed to turn to an open platform control system that could provide operations at the highest international standards while allowing for local design and development of turbines. With its system integrator, the company built a solution based on the Rockwell Automation Integrated Architecture™ system.

Wind Power

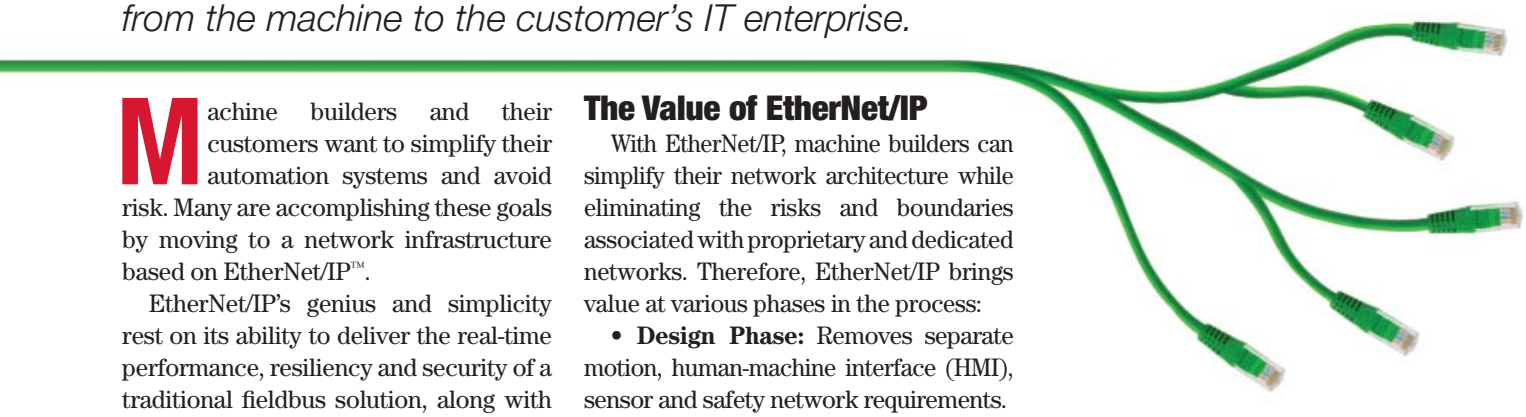
The Changxing 850 kW turbines utilise an Allen-Bradley CompactLogix™ programmable automation controller coupled with Allen-Bradley servo drives, IO and human machine interfaces (HMIs). The system communicates over a DeviceNet™ network and includes FactoryTalk® View Supervisory Edition HMI software for real-time information and data collection.

The application of this distributed and scalable architecture allows Changxing to interconnect all 58 of its 850 kW turbines for synchronised control. The ability to simultaneously control all the turbines streamlines operations and greatly improves the project's efficiency. With an open platform, the company also can develop innovative turbine components in-house, meeting government regulations for sourcing and furthering development of the local Chinese wind power market.

This project has become a successful application of Rockwell Automation® solutions in China's wind power field and has established a firm base for the company to further develop in the wind power field. Rockwell Automation has worked with Changxing to realise self-innovation in variable pitch blade and main control systems in wind power generator units; reduce production and maintenance costs with a universal control platform; help ensure further system upgrades with an open system; and improve overall competitive ability. Finally, Rockwell Automation has collaborated with Changxing to obtain international certification and expand overseas business with CE certification for the Rockwell Automation Integrated Architecture products. AT

Leverage EtherNet/IP to Reduce Network Integration Risks

Convergence with EtherNet/IP helps simplify control and information flow from the machine to the customer's IT enterprise.



Machine builders and their customers want to simplify their automation systems and avoid risk. Many are accomplishing these goals by moving to a network infrastructure based on EtherNet/IP™.

EtherNet/IP's genius and simplicity rest on its ability to deliver the real-time performance, resiliency and security of a traditional fieldbus solution, along with the bandwidth, open connectivity and global acceptance of standard Ethernet.

Converging to EtherNet/IP helps eliminate the need for machine builders to design, integrate and maintain multiple networks – a move that reduces the Total Cost to Design, Develop and Deliver℠ machines – while bringing new performance-boosting capabilities to their customers.

One Standard Network

Traditionally, machine builders have used a dedicated network for each application. By replacing this multi-tier networking strategy with one standard network, machine builders can reduce their engineering time and integration risks.

Rockwell Automation® supports EtherNet/IP for network convergence. It is the only industrial protocol that is established enough to provide connection from the instrumentation level all the way up to the customer's IT infrastructure – and across applications, including discrete, process, safety, motion and drive control.

Also, EtherNet/IP is the only industrial network built on standard TCP/IP technology – the same Ethernet standard as e-mail, the Internet and other commercial applications. Other industrial Ethernet protocols require proprietary chipsets and hardware, which can hinder innovation and system longevity.

The Value of EtherNet/IP

With EtherNet/IP, machine builders can simplify their network architecture while eliminating the risks and boundaries associated with proprietary and dedicated networks. Therefore, EtherNet/IP brings value at various phases in the process:

- **Design Phase:** Removes separate motion, human-machine interface (HMI), sensor and safety network requirements.
- **Develop Phase:** Provides a single approach to configuring devices with reduced debugging and interlocking code to write.
- **Deliver Phase:** Makes it easier to integrate a machine into the customer's environment since an Ethernet protocol natively conforms to the customer's standard factory and enterprise network infrastructure.

After the machine is running, EtherNet/IP continues to bring value. For example, technicians can directly connect to the machine from a remote location and conduct a detailed diagnosis using video, voice and other technologies enabled by Ethernet. The same capabilities can be used to order replacement parts or OEM-supplied raw materials.

Also, machine builders can leverage EtherNet/IP to help their customers effectively converge machine-level data with business-level data for improved management and decision-making. For example, Edson Packaging is a machine builder that has traditionally used a SERCOS interface® for its high-speed motion. It chose to use EtherNet/IP so its customers could converge to a single network for both machine and motion control. Its latest case packer uses EtherNet/IP and Stratix 8000™ managed switches from Rockwell Automation to effectively manage real-time control and information flow from the machine to the customer's manufacturing and IT enterprise (*http://ab.rockwellautomation.com/networks-and-communications/stratix-8000-ethernet-switches*).

For Askim Mek Verksted (AMV), a Norway-based manufacturer of cold-end glass wool production machinery, EtherNet/IP opened up some exciting new capabilities. Now, every aspect of AMV's packaging system can be monitored for effective maintenance and rapid fault diagnosis, from pneumatic valve operation to motor temperatures. EtherNet/IP also allows comprehensive remote diagnostics and machine management over the Internet through a secure Virtual Private Network (VPN).

With shrinking corporate engineering staffs and more pressure to bring systems online quickly, manufacturers are relying on their machine builders to deliver machines that integrate seamlessly with their existing systems.

Using standard Ethernet and IP network technology, EtherNet/IP is the best pathway to a converged network architecture. It helps simplify control and information flow from the machine to the customer's IT enterprise. AT

on the web

For more information on Rockwell Automation machine builder solutions, visit *http://www.rockwellautomation.com/solutions/oem/*