Ten principles of sustainable design

Ignoring the tiny details in a design can cancel efficiencies gained by tweaking larger options.

GuardMotion is the basis for safety integrated into Allen-Bradley Kinetix motion products. Tasks such as machine setup, cleaning, removal of jams, and other typical maintenance work that need power-down conditions can now be accomplished without removing power from the entire machine. As a result, machines typically have shorter downtimes and enjoy faster restarts. In addition, these devices help eliminate input components such as input contactors, simplifying machine design and reducing panel space requirements.

Manufacturers across many industries increasingly emphasize sustainability. When it comes to building machines, cost is no longer king. New designs must improve safety, minimize waste, and consume less energy. Design-for-sustainability takes a holistic approach analyzing operational efficiency, safety, functionality, productivity, material use, ease of operation, and maintenance.

Following these 10 best-practice design principles should help machine builders move toward sustainable designs:

1. Eliminate nonessential mechanical-drive components.

Simplified designs with fewer components run more efficiently and are less expensive to build. Older mechanical power-transmission and actuator technologies, such as chain, rack-and-pinion, and worm drives, often stand in the way of more-efficient designs. These older devices use components that wear over time and demand frequent maintenance, including lubrication and tensioning.

Designers rely more and more on sophisticated performance and simulation software to help eliminate many unnecessary components such as line shafts and

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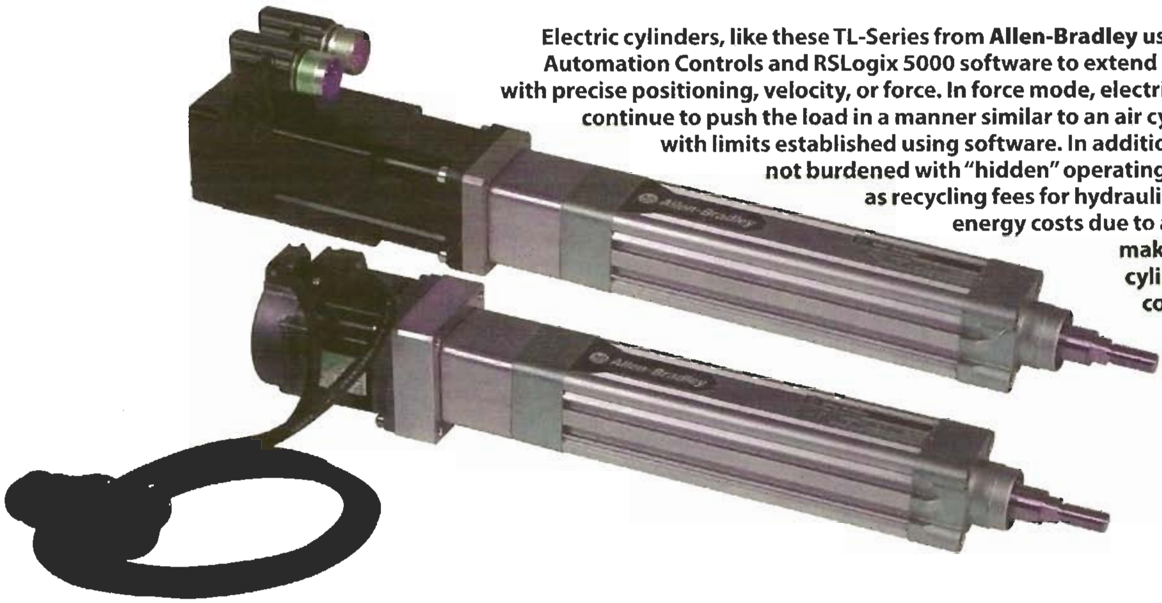
Key points:

- Simplified designs run more efficiently and are less expensive to build.
- Embedded data-gathering systems garner machine status at the source to more-accurately predict and prevent failures.

Resources:

Allen-Bradley, *www.ab.com* **Circle 621**

Rockwell Automation, *www.rockwellautomation.com* **Circle 622**



Electric cylinders, like these TL-Series from Allen-Bradley use Rockwell Automation Controls and RSLogix 5000 software to extend and retract with precise positioning, velocity, or force. In force mode, electric cylinders continue to push the load in a manner similar to an air cylinder, but with limits established using software. In addition, they are not burdened with "hidden" operating costs such as recycling fees for hydraulic fluids and energy costs due to air leakage, making electric cylinders more cost effective over the long term.

costly pneumatics and hydraulics. With these mechatronic tools, engineers can analyze energy use, build virtual prototypes, and select the best mechanical design to maximize performance. This approach reduces energy consumption and maintenance costs while improving uptime and reliability.

Machine builders also use direct-drive motion technology to improve mechanical efficiencies. This technology helps create more accurate, reliable, and energy-efficient machines that are less costly to maintain. For example, a **Rockwell Automation** customer replaced a motor-worm gearbox with a direct-drive servomotor that boosted the mechanical efficiency of the machine from 29 to 98%. The efficiency realized with direct-drive technology lets designers use smaller servodrives that, in turn, use less energy.

2. Minimize the mass of essential mechanical components.

After eliminating all nonessential mechanical items, the next step is to minimize the mass of what remains. The wide breadth of analytical, modeling, and development tools makes this task easier. Such tools can also test a machine's mechanical performance envelope using advanced stress and strain-analysis techniques. This lets designers evaluate potential alternative materials that are lighter and more energy efficient.

Design techniques widely used by the aerospace industry minimize the weight of structural components without compromising strength. Machine builders can use 3D computer-aided design and finite-element-analysis tools to optimize the mechanical design as structural elements can take on more complex shapes. Advanced fabrication equipment can shape and mill contours in structural components that eliminate superfluous material. Furthermore, the removal of excess material directly reduces the force needed to move the mass of the structure, letting designers choose smaller motors and drives that consume less energy.

3. Substitute electric actuation for fluid power.

Wherever possible, use electrical actuation rather than hydraulics and pneumatics. Though hydraulic and pneumatic actuators may have a lower initial purchase price, they also typically have high hidden costs, such as expensive recycling fees for hydraulic fluids and operational energy costs.

Electric cylinders combine high speed with high accuracy, repeatability, and reliability. Furthermore, their modular design allows them to fit a wide range of machines. Controls for electric cylinders range from simple indexers to more complex programmable, multiaxis motion controllers, giving designers more choices and allowing them to better weigh the cost and benefits of each.

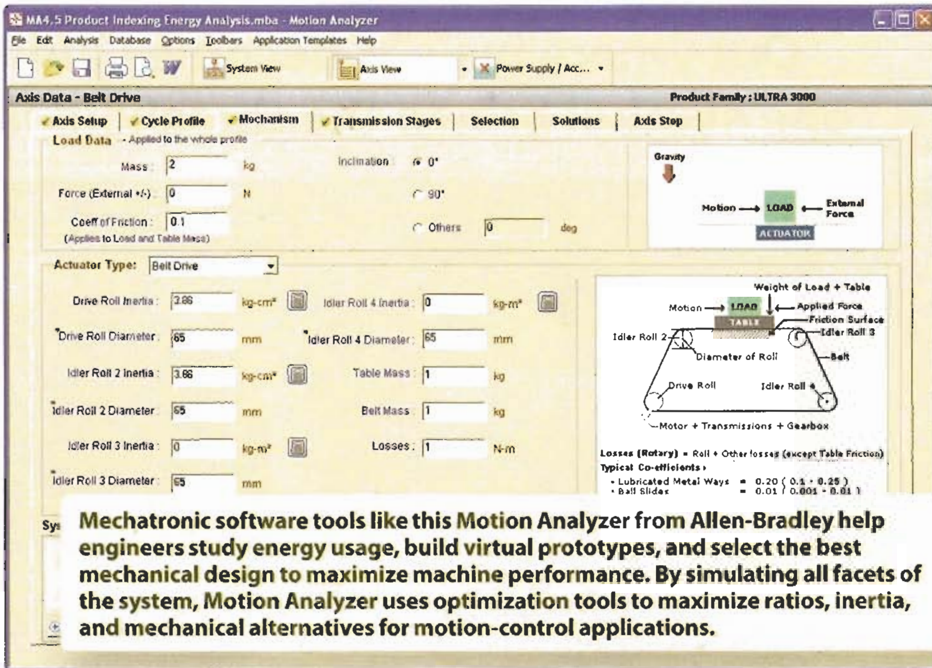
4. Perform a safety audit after mechanical design, but before control-system design.

A safety audit helps engineers evaluate and investigate risks early in the development process. It identifies the required safety-control-system integrity level and helps guide the selection of the overall control architecture. By performing the audit before the control system is designed, safety can be made an inherent part of the control system rather than a tacked-on afterthought. This saves critical time and helps machine builders get their equipment to market faster. In addition, end users gain optimized production, thanks to an automation system that helps operate machinery and processes in the most-efficient and safest way.

5. Guard or control access to moving parts.

Where hazards cannot be removed through design, machine builders typically install a fixed physical barrier that protects users from the hazard. Nonfixed guards such as removable, swinging, or sliding doors find application where there must be frequent access to the hazardous area. In areas where nonfixed guards are impractical, safety systems can monitor the presence of the operator.

While relays and other devices prove effective, many safety applications require a level of programming or more sophisticated safety logic that is best met through a safety controller. Safety controllers offer significant benefits in multistep shutdown or ramp-down sequences, as in transfer line applications, because they provide the necessary logic through software rather than the hard-wired logic of relays. An integrated safety controller works well for any application that needs these advanced functions, such as zone control. Properly designed safety controls and guarding reduce access time and help make machines safer and more efficient.



Mechatronic software tools like this Motion Analyzer from Allen-Bradley help engineers study energy usage, build virtual prototypes, and select the best mechanical design to maximize machine performance. By simulating all facets of the system, Motion Analyzer uses optimization tools to maximize ratios, inertia, and mechanical alternatives for motion-control applications.

6. Integrated safety systems reduce control-system complexity.

The more designers integrate standard and safety control functions, the better the opportunity to eliminate duplicate equipment, boost productivity, and lower costs. Integrated controls reduce the number of special components on the factory floor which, in turn, reduces crib inventory costs as well as maintenance-team training. End users benefit from less waste with fewer parts to maintain and replace throughout the machine life cycle. In addition, integrated control systems give broader access to data about machine operation and status. This lessens the number of nuisance shutdowns and prolonged restarts, further improving machine efficiency and productivity.

New safe-speed control systems are great examples of effective control integration. With safe-speed control, safety input devices such as guard-locking switches, light curtains, and emergency stops, link directly to the speed-monitoring core of the control. Rather than triggering a full shutdown of the equipment when the safety system trips, safe-speed control reduces operating speeds to levels that provide acceptably safe human and machine interaction. This eliminates the need for a separate, dedicated safety controller while providing use across multiple platforms.

Safe-speed control lets operators perform maintenance and other tasks while a machine remains in operation. Safe-speed control also helps boost uptime and lowers energy costs because a machine need not be completely shut down and then restarted.

Networking offers another way to integrate safety and standard controls. The introduction of networks to the plant floor brought many benefits to manufacturers, including more productivity, less wiring, better diagnostics, and easier access to plant-floor data. Using an existing network to handle safety information creates seamless communication of the complete automation process on one standard set of network hardware and wiring.

7. Distribute control and interface devices near point of use.

While some control components traditionally reside on the machine, technology advancements make it possible to move entire control systems close to the application point. Standard automation components — including controllers, motor starters, drives, sensors, contactors, network media, distribution boxes, I/O, and HMI devices — have become on-machine applications.

On-machine design reduces design and installation time along with the labor needed to assemble the system. This approach also helps eliminate installation mistakes because there are fewer wire runs and manual connections. In fact, some machine builders have seen their total machine tear down and reinstallation time drop more than 50%.

For end users, the compact nature of on-machine controls frees up the plant floor to reduce overhead and conserve energy.

8. Develop modular code.

Programming can consume up to 80% of the control-system design budget. Modular application development generates and reuses programming code modules as outlined in standardized programming methods and models such as ISA-88. Using the same specification document throughout the process helps cut engineering time and improve the quality and consistency of the design.

In the same vein, information storage from one program to the next remains consistent with data found exactly where the engineer expects it to be. The ability to troubleshoot multiple programs the same way boosts uptime. Moreover, customers get up to speed quickly when programs have the same look and feel.

9. Make better use of diagnostics.

It is now easy to embed data-gathering devices into machine controls. This lets equipment monitor itself to predict and prevent failures. Moreover, this technology can relay machine status back to the machine builder for value-added monitoring and analysis services without compromising existing resources or hindering profitability.

Machines designed with Ethernet and Internet connections permit remote troubleshooting with obvious implications for maintenance cost. For example, the ability to remotely monitor equipment from a distant location saves fuel, cuts emissions, and virtually eliminates travel time and related expenses.

10. Design IT connectivity into the machine.

Machines capable of connecting to an IT infrastructure can provide information for energy efficiency and overall equipment-effectiveness (OEE) calculations that help plant managers reduce waste and optimize productivity.

IT connectivity also helps maximize the benefits of track-and-trace capabilities. Using advanced information software, manufacturers can track and record relevant data at every step of the process to identify when and where resources were used. This visibility offers end users a wealth of data for waste reduction and other improvement programs.

In addition, these systems also help track product genealogy through the full chain of custody. In so doing, they help document data required by regulations, identify potential product quality issues before they reach the market, and, if necessary, respond faster to product recalls. **MD**