LIFECYCLE INSIGHTS

THE DIGITAL APPROACH TO INDUSTRIAL MACHINERY DESIGN

Creating Equipment that Increases Cycle Speed and Improves Yields

THE DEVELOPMENT CHALLENGE OF INDUSTRIAL MACHINERY

Today's engineers face unprecedented challenges when designing industrial machinery. There is a growing expectation that new designs will increase cycle speed and improve yields—all while producing fewer defects—and that such machines will be delivered and commissioned faster than ever before. Complexity is rising dramatically in traditional mechanical and electrical design domains. And software plays an increasingly significant role as industry sees the value of streaming data off connected equipment.

Despite these challenges, manufacturers must contend with continually shrinking development timelines. As a result, engineers must find a way to do more with less. This means adopting shift-left methodologies, which rely on digital approaches, to verify behavior and performance early in the development process.

This eBook provides an overview of the latest advances modern companies are harnessing to develop more complex machinery and equipment on shorter schedules. Here, we highlight several common development challenges and the progressive approaches, including practices and technologies, that best address them.

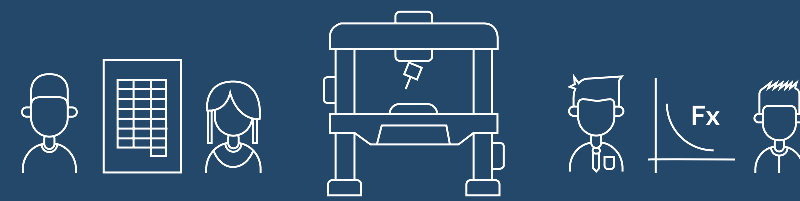
Today's engineers face twin challenges in developing industrial machinery. Complexity is rising fast, making it more difficult to satisfy increasingly competing or conflicting requirements. And shortening schedules are forcing engineers to get more done in less time.

ADDRESSING STRUCTURAL STRESS AND STIFFNESS

Industrial machinery has stringent structural requirements around deflection or deformation for operation, resulting in fine dimensional tolerances. Engineers must manage and control stresses throughout the machine to avoid structural failures. To do so, they have to understand how industry machinery may flex and strain during operation.

Traditionally, engineers identify problem areas by performing complex manual calculations according to industry standards. But as machines grow more complex—carrying higher loads and using more electromechanically actuated components—these manual equations are more likely to miss potential failure points. As a result, machines can end up working outside of specific requirements, undermining production or operation.

Leveraging powerful high-fidelity modeling and simulation tools is a more progressive approach. Engineers can use these tools to simulate the performance of a full-featured machine model quickly and easily. They can ensure that any abstractions won't undermine analysis accuracy. Using simulation technologies, engineers can analyze large assemblies as they explore design alternatives to fully understand the implications of different design decisions. These tools provide the kind of insights that will reduce—or even eliminate—late-stage operations issues.



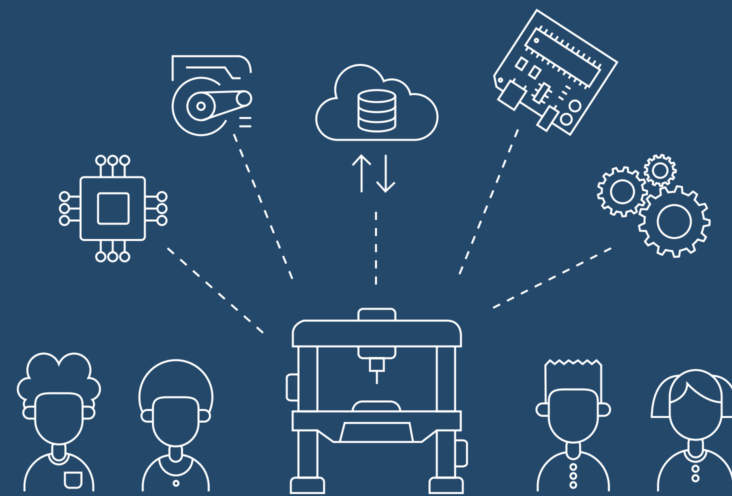
Modern industrial machinery must operate on tight constraints and requirements, forcing engineers to mitigate structural stress and stiffness. Traditional, manual calculations fail to capture the complexity of modern industrial machinery. Powerful, high-fidelity analyses provide fast, more accurate results that facilitate more informed decisions.

ARCHITECTING AND VALIDATING SYSTEMS DESIGN

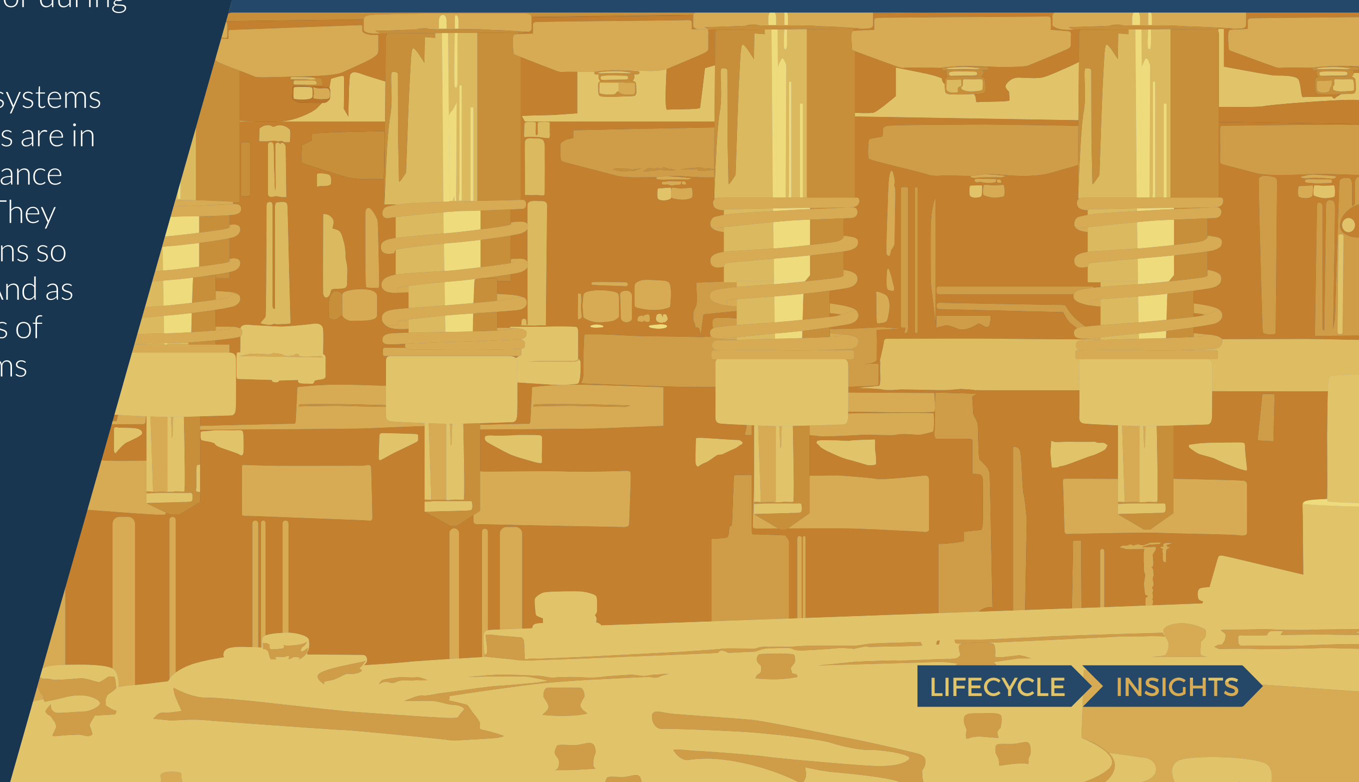
Industrial machines are becoming more and more complex, especially across engineering domains. Today's designs likely incorporate mechanical, electrical, electronic, software, and internet-of-things (IoT) connectivity characteristics. With so many factors in play, it can be challenging to come up with the right architecture to meet all domain requirements. Once detailed design work begins, it is hard to continually verify behaviors and performance during the development process.

Historically, design work has been siloed, as engineers work in their respective domains to satisfy requirements within each of their disciplines. This works—to a point. Once it's time to put all the pieces together, machinery can develop unintended behaviors and miss various performance requirements. Too often, such issues only manifest after installation or during commissioning, creating substantial delays.

But engineers who leverage systems design and systems simulation tools to develop machine architectures are in a better position to verify behaviors and performance early and throughout the development process. They can conduct trade studies across different domains so they can make more informed design decisions. And as the different engineering teams fill out their parts of the design, the simulations help verify that systems behavior works as intended across domains.



Modern industrial machinery is a complex combination of mechanical hardware, electronics, electrical systems, and control logic. Figuring out the right architecture, the correct combination of these components, is a significant challenge. Systems design and systems simulation tools allow engineers to develop, analyze, and iterate on this architecture to ensure it fulfills the right requirements

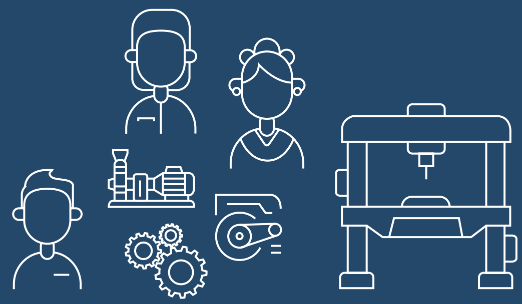


SELECTING THE RIGHT ACTUATION COMPONENTS

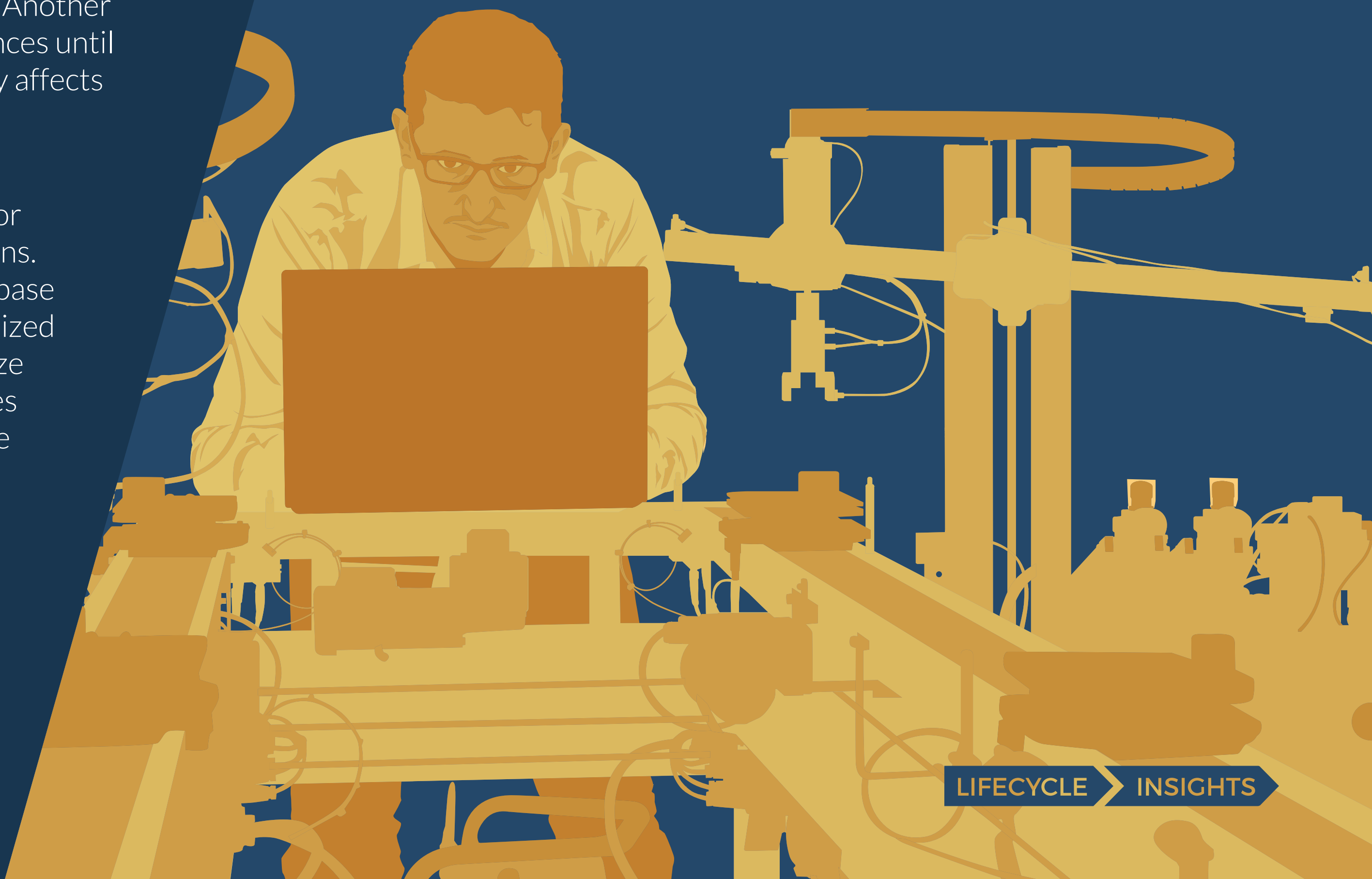
Today's industry machinery is increasingly reliant on electromechanical equipment for motion and actuation. The electrification of equipment comes with a variety of risks that can lead to later machine failure, so it is increasingly important to appropriately size electromechanical components.

This can be a struggle for industrial equipment manufacturers. Those that use oversized motors, pumps, and other off-the-shelf components in equipment spend more than necessary. The converse issue is just as problematic, however, where undersized components fail to power the machinery's intended features. Another issue lies in the inability to identify interferences until late in the development process. This directly affects costs and scheduling deadlines.

Engineers can leverage multi-body dynamics simulations to identify the appropriate size for actuator components for different applications. They can use these simulations to configure base designs to quickly model and analyze customized machines and determine what component size will be best for the job at hand. Doing so saves manufacturers both time and money over the entire development process.



Today's industrial machinery relies heavily on off-the-shelf components for actuation and movement. Selecting right-sized components, however, is no easy task. Undersized or oversized components can lead to poor behaviors or unsatisfied requirements. Multi-body dynamics analyses can empower engineers to make better decisions.



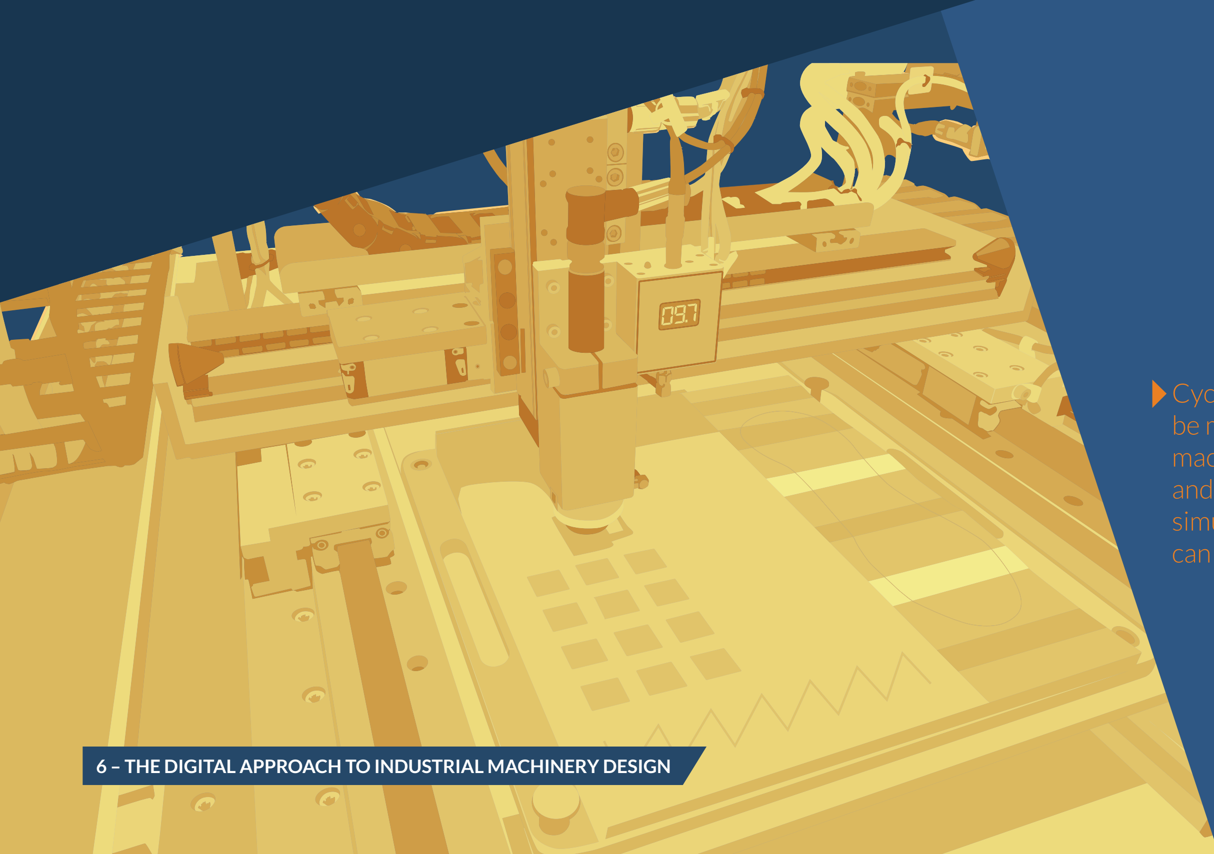
MITIGATING VIBRATION AND EXCITATION

Machinery and equipment that support discrete or continuous manufacturing processes use motors, pumps, and other components that emit cyclical forces. These can cause vibration and excitation throughout the equipment, potentially undermining the machine's fine operating tolerances. In some cases, these issues can lead to catastrophic failure. Understanding how vibration and excitation may affect the operation of industry machinery is vital.

Traditionally, engineers use past experience coupled with rough calculations to determine the modes of components and assemblies. This approach, however, makes it difficult to determine such characteristics for complex designs, especially as those designs are modified over time. The result is often unintended behaviors that aren't discovered until installation or commissioning, and that may lead to failures.

In contrast, engineers who leverage dynamics simulations can interactively explore different design configurations. They can ensure modes are out of the ranges of the cyclical loads applied by motors and other actuated components. By tightly integrating design and simulation, engineers are better positioned to identify any vibration or excitation issues early on in the design process.

Cyclical loads are an inherent part of industrial machinery that must be mitigated for performance. The increasing complexity of today's machine, however, make it difficult to determine modes of components and assemblies using only experience. Conducting dynamics simulations provides engineers insight into performance and how it can be changed to meet requirements.



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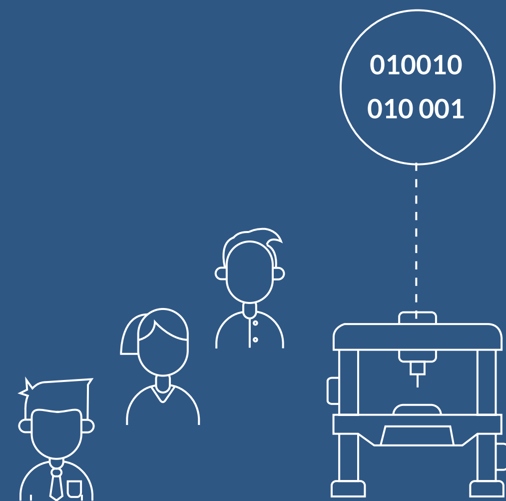
PLANNING AND VALIDATING CONTROLS DESIGN

As industry machinery grows in complexity, the need for controls becomes even more important. The capabilities delivered by programmable logic controls (PLCs) or other controllers now offer a variety of smart features that can help companies better manage production equipment. While companies do not expect design engineers to be full-time programmers, they must be able to accurately define the behaviors their designs will exhibit.

In the past, engineers would submit the logic they wanted programmed into any controller to a software engineer and then wait weeks for that task to be completed. This approach also meant that any programming issues were not exposed until the commissioning phase after installation. The end result: costly delays in time-sensitive situations.

Today, engineers can program controllers independently in a visual programming environment. Using a diagram-like interface, engineers can easily develop the logic that drives the machine's behavior. There is no waiting for software engineers to complete tasks. In this approach, engineers can connect the logic to a simulation of the machinery and validate its behavior in a digital environment long before the machine is physically installed or commissioned.



Logic controls are a crucial piece of industrial machinery. Working through control programmers causes delays and misinterpretations of the design engineer's intent. Visual programming tools, instead, allow engineers to directly build and verify their logic.

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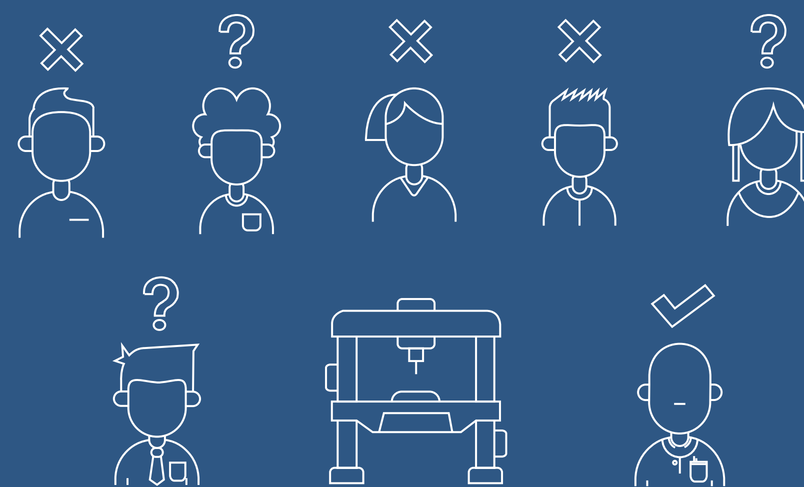
STREAMLINING COMMISSIONING

Industrial equipment differs from other types of products in that it must be installed and commissioned as part of the final delivery process. To make that happen, manufacturers often have to shut down their production systems. Naturally, they want to minimize the amount of time their manufacturing environments are off-line.

Historically, organizations have scheduled a significant amount of downtime to support installation and commissioning. This means lost revenue, which these companies account for because they simply cannot produce their products during downtime. But problems arise when the commissioning process takes longer than anticipated. When the production systems are down longer than intended, the equipment manufacturer often incurs financial penalties.

When manufacturers can take a virtual commissioning approach and digitally simulate the operation of the equipment, they can identify and resolve any potential issues that may crop up during commissioning. Using these digital simulations can address issues early and ultimately reduce the length of the physical commissioning process.



Commissioning industrial machinery can be a risky endeavor. Debugging control logic and other systems behaviors can take days or even weeks. Virtual commissioning allows engineers to digitally test machinery long before installation, enabling them to uncover and resolve problems much earlier.

MONITORING THROUGH FIELD DATA

In the IoT era, nearly every product in every industry is being transformed to connect and stream data. The advantages are clear: Having access to this data allows manufacturers to closely monitor their equipment and machinery, proactively servicing those systems to avoid or minimize downtime.

One approach to making a product IoT-ready is to load it down with sensors. Yet, this strategy often overwhelms companies with the resulting amount of data. There is just too much information to sift through. Such information overload can lead to inaction, undermining the effort's overarching purpose to support proactive maintenance and maximized uptime.

The progressive alternative involves simulating the operation of machinery while taking measurements from virtual sensors. Engineers can then determine the right configuration for proactive maintenance—just what sort of sensors to use and where to place them. They can also identify what leading indicators should be monitored. And as artificial intelligence (AI) and machine learning capabilities grow, companies can leverage these new technologies to analyze the resulting data and identify anomalies that correlate to events manufacturers want to avoid.

Streaming and analyzing data from industrial machinery offers an opportunity to gain more insight into the operation of equipment than ever before. Augmenting this real-world data with simulations, artificial intelligence, and machine learning only strengthens the value of these activities to engineers.

RECAP AND CONCLUSIONS

The need to design more complex industrial machinery on shorter timelines means that companies are asking engineers to do more with far less. That said, the adoption of shift-left methodologies that rely on digital design approaches can help engineers create equipment that increases cycle speed and improves yields. Adopting progressive digital approaches helps engineers address design concerns early in the product development process— long before installation and commissioning. Using these approaches, engineers can:

- Leverage modeling and simulation tools to explore design alternatives, and fully understand the implications of design decisions that may influence structural stiffness and stress.
- Harness systems design and systems simulation tools to develop machine architectures, conducting trade studies across multiple engineering domains to make more informed design decisions and verify behavior.
- Use multi-body dynamics simulations to identify the appropriate size for actuator components to better manage the electrification of modern machinery.
- Rely on dynamics solutions to identify the modes of entire machines in order to better mitigate any problems arising from vibration and excitation.
- Take a virtual commissioning approach to identify and resolve any potential design issues before installation and commissioning.
- Explore opportunities to apply artificial intelligence and machine learning to field data analysis, enabling proactive service of machinery to avoid or minimize downtime.