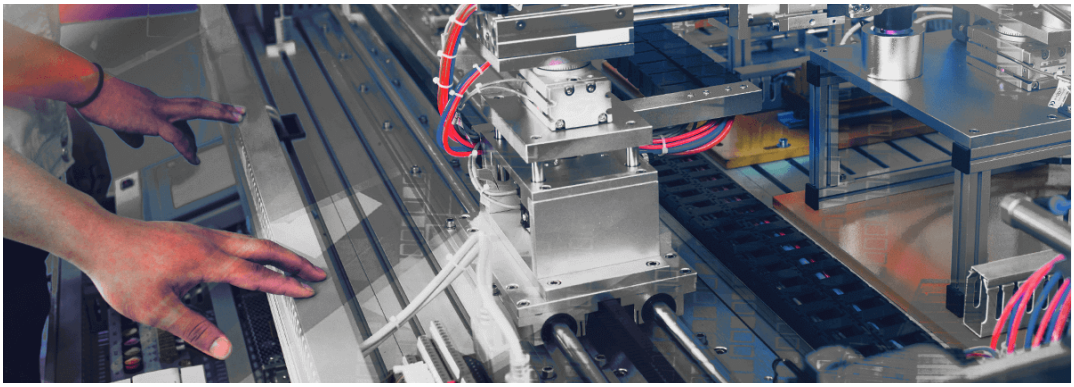
WHAT IS SIMULATION DOING FOR MACHINE BUILDERS?

A key development goal of any machine-building project is to produce perfectly running, reliable machines that make high-quality products. By leveraging accurate virtual prototypes, seamless production can be ensured earlier in the development process to help assess and improve product profitability. Whether you develop process and packaging, CNC tooling, textiles, special purpose machines or provide mechanical machinery engineering services, the efficient interdisciplinary exchange between design and development departments is essential to bring structural, electrical, and control elements of a machine together.



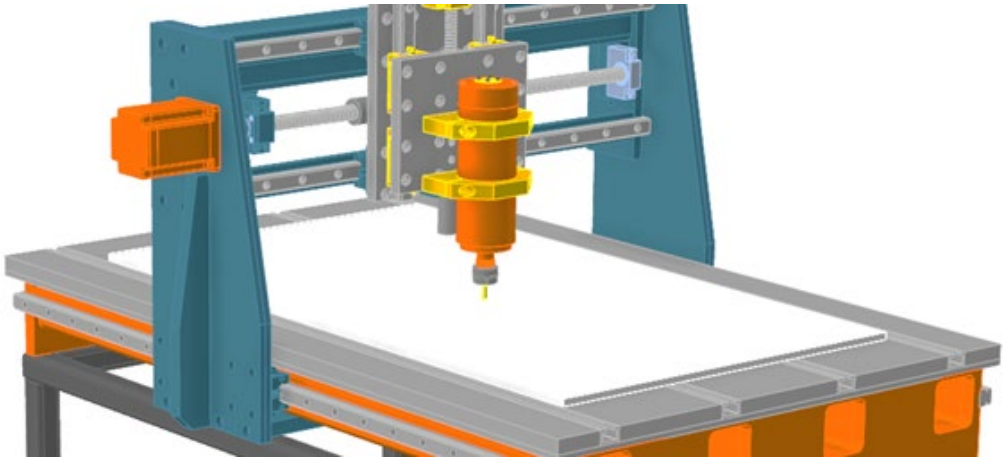
Altair simulation tools enable accurate virtual prototyping to help companies become more agile and independent of unforeseen external constraints. By utilizing these tools, it's possible to combine mechanical, actuator, and control engineering early in the design cycle to find efficient and cost-effective solutions. To ensure perfectly running production earlier, Altair's integrated product and process simulation tools come together to give a holistic system view.

Considerations for a Machine Builder Using Simulation Tools

- Simulation strategies need to ensure the quality of the final product by encompassing the entire process with all its variables, including the products produced by the machine.
- Accurate virtual prototypes that represent machine behavior are needed to properly size drives and mechanics, safely increasing cycle rates while maintaining accuracy, precision, and robustness.
- Effective durability and fatigue assessment are necessary for ease of preventative maintenance scheduling.
- System simulation to optimize control systems for faster commissioning.

Simulating a CNC Milling Machine

3-axis CNC milling machines are used for automatic and interactive processes, covering a range of operations including milling slots, drilling holes, or cutting sharp edges. As the name suggests, 3-axis machines have three axes and are used when the operation requires a simultaneous and controlled movement of the X, Y and Z axes. Using this as an example, we will show you how Altair's simulation tools tackle all the previously mentioned considerations, offering a comprehensive evaluation of a real-world machine.



A model of a CNC milling machine

Improve System Understanding With Dynamic Motion Analysis

Using Altair® Inspire™, it's possible to gain an understanding of the actual behavior of a machine assembly and identify peak loads which are essential when building a machine such as this. This process can be broken into 4 parts:

Represent Joints and Connections Accurately

The accurate representation of a machine behaviour in a simulation is influenced by the representation of the connecting elements. Elasticity or friction in a bearing, the load applies in the assembly process or the contact interactions of moving parts; all affect the behaviour of the model. In Inspire, this process is simple and straightforward thanks to inbuilt features. Connecting parts with screws or pins is also simple thanks to an automated process that identifies probable connection points, with options to select specific types of fasteners.

Add Motors and Movement Profile

Simulating realistic motor behavior and machine movement is essential when building an accurate model for machine building. Inspire makes it possible to add motors and import customized movement profiles easily, providing key instructions about motor behavior.

Setup and Run Motion Simulation

Important parameters such as duration of simulation and output frequency can be set. Accompanied by animation while Inspire's powerful solver runs in the background, this makes it easy to overcome initial failures from the very start, preventing time and cost loss.

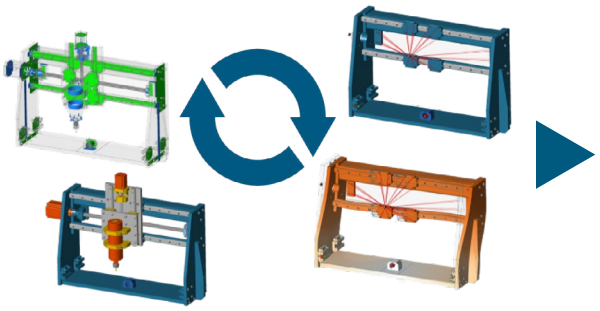
Identify Loads and Check Validity

An essential step in machine building is identifying peak loads on parts, such as screws or welded connections, to ensure structural integrity. This can be done individually for every part or collectively, helping the user to easily identify peak loads and invalid forces. Other key insights such as required drive torque and motor power are also possible to obtain, ensuring functionality.

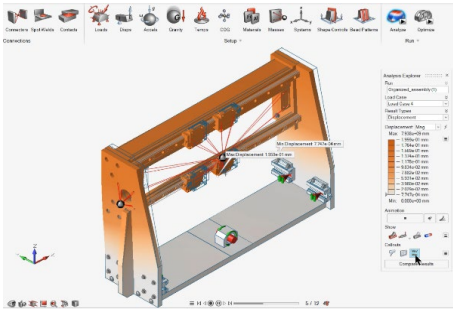
For a detailed insight, watch this presentation.

Accurate Structural Assessment With Real Loading Conditions

Another important aspect of machine building is ensuring an accurate structural assessment is performed to increase the accuracy of the machine. Stresses and deformations can be considered, comprehensively saving money and increasing durability. Additionally, a proper evaluation of connection forces to define the number and dimension of bolts is needed to improve the overall machine performance, all possible with Inspire.



Accurate structural assessment with real loading conditions



Machine portal deformation

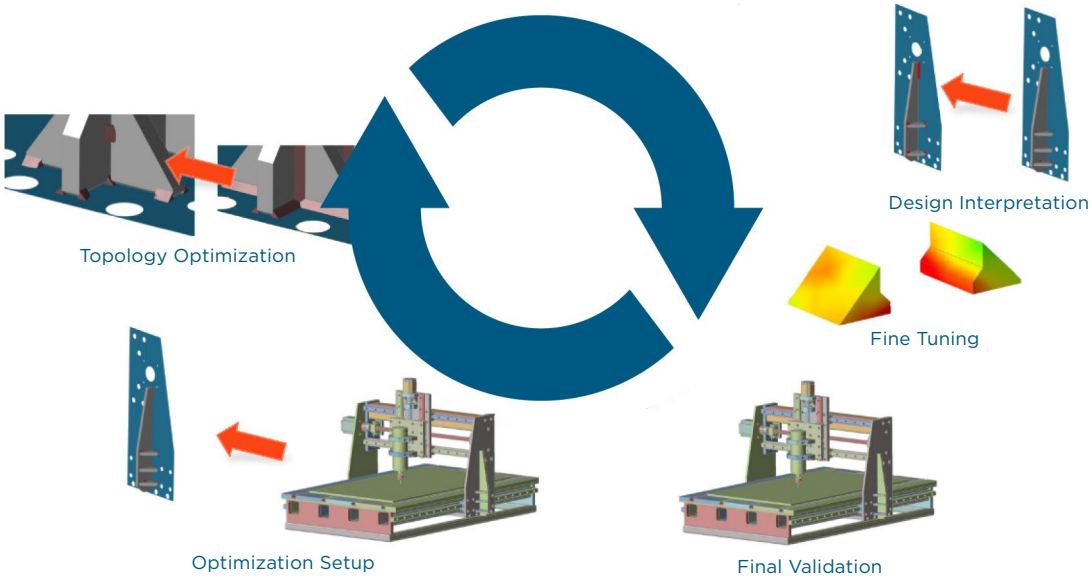
Advanced Capabilities

Diving deeper, if you need to access more detailed structural analysis insights, Altair® HyperWorks® provides advanced modeling capabilities such as full mesh control, elastoplactic material behavior, and advanced optimization setup leveraging the Altair® OptiStruct® solver.

For more information, watch this presentation.

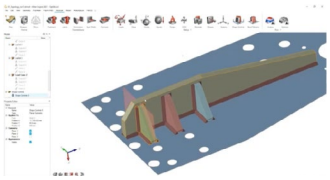
Improve Design With Studies and Design Exploration

Specific to our CNC milling machine example, topology optimization and weld line optimization can be achieved to reduce design development time and associated costs. Applied early in the development the design process is accelerated and manufacturing time and material is reduced. The image below specifies a typical topology optimization design loop related to design exploration and optimization using Altair simulation solutions:



Topology Optimization

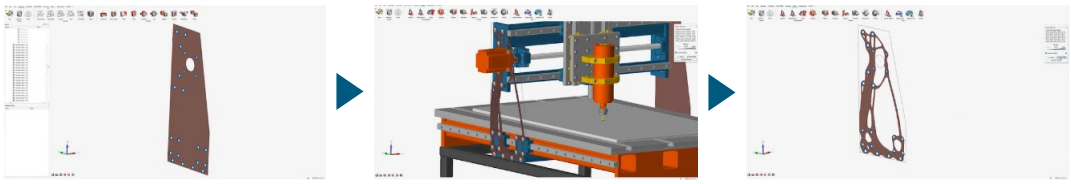
By performing topology optimization, it's possible to identify areas of less important structural significance and therefore reduce the overall weight of the assembly. This process starts by defining the design space and adding manufacturing constraints such as ideal material stiffness and the minimum thickness of specific components. Assuming the topology optimization is successful, these results are automatically loaded back into Inspire for user review and key weld areas are identified for additional structural support.



Topology Optimization

Vibration Reduction

Using Altair's simulation solutions it's possible to reduce vibration with topology optimization by performing a modal analysis and optimization of the machine portal. This approach removes any unnecessary material while improving the overall system performance and ensures the functionality of parts.



Create Design Space | Run Topology Optimization | Recreate Shape to CAD Model

In the example shown above, Inspire Motion was used to investigate this further. The results showed a 71% dynamic weight reduction leading to significant time saving in the development process.

To learn more, watch this presentation

Weld Line Optimization

Identifying necessary weld line locations and reducing weld lines through topology optimization is also possible using Inspire. In this example, the stress and displacement levels were set to stay within a given limit resulting in a weld reduction of around 85%, from 728mm to 111mm of overall weld line space.

Design Studies on Complete Assembly

Understanding how the complete assembly behaves after certain parameters or components are changed is highly important. By incorporating our multidisciplinary design study software Altair® Hyperstudy® into the development process, a design of experiments process can be performed and design variants can be compared, leading to the most optimal design possible.

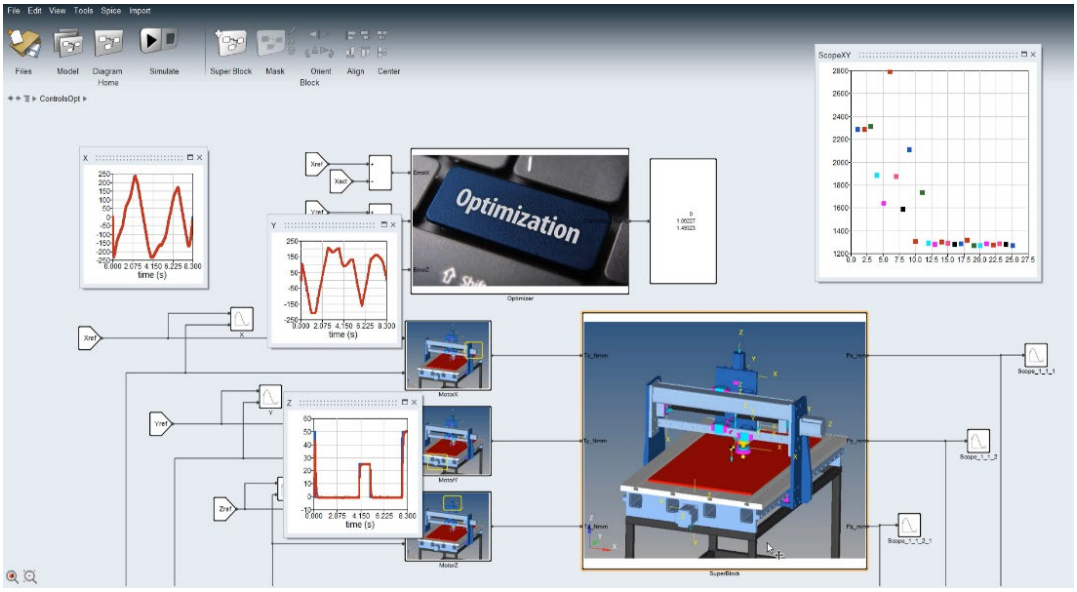
To learn more, visit watch this presentation.

CNC Control Optimization

Optimizing the speed and precision of machines is vitally important in the development stage, as the success of the final product relies on the mechatronic and control systems to behave as intended. Undesired vibration leading to noise emission or reduce fatigue, imprecise dimensioning of drive components, or overheating problems are all potential failures when building a CNC milling machine for example. The more complex the machine, the higher the chance of insufficient understanding of all phenomena leading to unknown root-causes of degradation effects and breakdown.

Mechanical CAD, Electrical CAD and control software development is often sequential. Before the complete machine is detailed out in CAD, the overall system behavior of mechanics, electric sensors and actuators and the controlling software need to be harmonized. Joining development disciplines with purpose driven simulation, the system development solution Altair® Activate® connects with virtual commissioning environments through the functional mockup interface (FMI) standard. Combining control sequencing with the actual behavior of the machine allows virtual commissioning and reduces the time investments at the customers facility. A holistic system simulation is possible, providing efficient modelling of real system behavior with flexibilities, contacts, gaps, frictions, power electronics and more.

To learn more, watch this presentation.



Working with Altair

The increasing complexity of machines requires active management of technical risks in developing new product lines, especially in customer implementation projects. You can achieve this through multi-physics simulation and model-based development to understand the phenomena and root causes of unwanted behavior. Using Altair simulation solutions, machine builders can solve a range of engineering problems to ensure machines are built right the first time.

By considering the entire machine operation process with all its variables including products produced by the machine, Altair allows users to build with confidence. Accurate virtual prototypes that represent machine behavior help to improve or maintain accuracy, precision, and robustness as well as providing durability and fatigue analysis. System simulation is also possible to optimize control systems for faster commissioning.

For more information about Altair's machine building solutions, visit our dedicated webpage.