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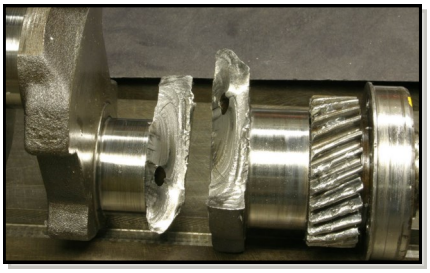

Avoiding Machine Failure

The cost of not identifying design flaws early in product development

Machines experience a wide variety of loads during operation that are rarely considered during design process. Early field failure leads to warranty issues, liability concerns, and loss of brand value and reliability, all of which are detrimental to a manufacturer.

In this play, you will learn about the various loads that cause early machine failure and how Autodesk® Nastran® In-CAD™ can simulate these loads upfront to predict field performance.

Target Profile

- At least 3 seats of 3D CAD (either Autodesk® Inventor® or SolidWorks®)
- Target Industry Sub-segments:
  - Industrial Process Equipment
  - Mining, Agricultural and Construction Equipment
  - Power Generation and Transmission
  - Fluid Power Equipment

Current Strategies in MFG for Machine Design

To meet the design and operational requirements, MFG firms often employ one or more methods:

- Use prior art/experience/tribal knowledge to make design decisions
- Perform simplified calculations with a number of assumptions/approximations to estimate strength
- Outsource design validation to consulting firms with expertise/access to simulation tools
- Simplify dynamic and cyclic loads into static load patterns to perform first-pass static FEA
- Build scaled models/full scale physical prototypes before production

Best-in-Class manufacturers

Perform upfront and contiguous design validation taking into account multiple failure modes and leveraging Simulation to influence design decisions at each step of product development.

Competitive Landscape

- **SOLIDWORKS SIMULATION**

Popular FEA product embedded within SolidWorks. Known for ease of use and high level of automation. Weak non-linear capabilities. Accuracy is questionable.

- **ANSYS DESIGNSPACE**

Entry level ANSYS FEA solution. Associative with major CAD tools, and offers scalability to complex high-end ANSYS products. Not a CAD-embedded solution. Limited analysis types with DESIGNSPACE. 2x-3x the cost for equivalent functionality.

- **PTC CREO Simulate**

Basic structural and thermal FEA embedded within Creo. Very little development by PTC since acquiring the code in 1995. Minimal non-linear capabilities or advanced simulation capabilities. Limited sales channel.

BRAND AND REPUTATION	Degradation of brand loyalty, assurance and satisfaction
QUALITY AND LIABILITY	Uncertainty around product quality; low confidence in designs
PROFITABILITY	Loss in Profits due to added cost of fixing warranty issues and reduced future sales potential
COMPETITION	Increase in competitive losses due to low credibility
PRODUCT DEVELOPMENT	Increase in ECOs; delayed time to market; longer development time; uncertainty in design quality leads to overdesign

Understanding Operational Loads

MFG firms design machines to withstand combinations of loads through their lifecycle. The magnitude and type of loads at any given time on a machine can dramatically impact its performance, durability, and longevity. Operational loads on machinery can broadly be classified into the following categories:

Load Type	Description	Example	Product Fit
Static	Time independent Loads	GENERAL: Stress on a chair based on person's weight INDUSTRY: Stress on a gantry crane from a hanging load	Inventor Professional; Autodesk Nastran In-CAD
Modal	Vibration-induced	GENERAL: Strumming a guitar INDUSTRY: Vibrating screens/conveyors	Inventor Professional; Autodesk Nastran In-CAD
Thermal	Temperature-based loads	GENERAL: Heat from a stove INDUSTRY: Thermal Stresses in amphibious craft	Autodesk Nastran In-CAD
Fatigue	Cyclic loads	GENERAL: Repeated stretching of a rubber band INDUSTRY: Early failure of pressure vessel	Autodesk Nastran In-CAD
Buckling	Compressive Loads	GENERAL: Collapsing an empty soda can INDUSTRY: Buckling of a highway light pole	Autodesk Nastran In-CAD
Dynamic	Constantly changing loads	GENERAL: Vibration during airplane take-off INDUSTRY: Dynamic loads on a compressor skid	Autodesk Nastran In-CAD

Common Challenges in Designing Machines

There are a number of other challenges that designers/engineers have to work with in designing machines:

- **Complex assemblies/modular designs** - Machines are getting increasingly complex with hundreds of parts held together by a number of fasteners (each of which can be a failure point)
- **Moving parts/Range of motion** - Machines are likely to have moving parts like pulleys, actuators, gears, transmission units, etc. All these contribute to the desired range of motion of moving linkages, support systems and so forth to achieve the desired operation. These can all contribute to the loads on a machine
- **Material choices** - Traditional materials like Steel and Aluminum are usually used, but more exotic materials from high strength/heat treated metal alloys to flexible rubber and plastic can also been used.
- **Shipping and transportation** - Most machines (large and small) have to withstand loads transmitted during shipping and transportation that is beyond operational loads

Going beyond Inventor Professional with **Autodesk Nastran In-CAD**

Autodesk Nastran In-CAD is purpose-built to help engineers perform comprehensive FEA within their CAD program. Autodesk Nastran In-CAD works within Autodesk Inventor and SolidWorks. Autodesk Nastran In-CAD allows a user to go beyond the static and modal analysis capabilities within Autodesk Inventor Professional to provide sophisticated capabilities within the design environment. It allows the user to:

- Use the Nastran solver within their CAD interface (currently supports Autodesk Inventor and SolidWorks)
- Study complex assemblies where assemblies comprise of solid, sheetmetal and weldments structures
- Simulate the response to temperature, buckling loads, dynamic and shock loads and study durability
- Explore alternative materials - from traditional metals and alloys to exotic plastics, rubber and composites
- Simplify fasteners for easy and intuitive virtual validation

With Autodesk Nastran In-CAD, a user can simulate various loads on assemblies within the CAD environment and identify flaws upfront in the design cycle. By studying dynamic and fatigue failure, the user can also prolong the life of the design by making early design decisions that impact its longevity.

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Top Reasons to Buy

1. CAD Embedded Simulation

- Leverage In-CAD to validate designs within the CAD environment (Inventor or SolidWorks). Standardize analysis platform across CAD tools
- Eliminate need to stop and send current state of design to an adjacent software/team because of limited Simulation capabilities

2. Physics beyond just Static Load Tests

- Full-featured solver enables you to study machine performance and a diverse range of failure modes
- Represent the design in its functional environment accurately with all contributing loads and materials

3. Predict lifespan of a machine

- Determine the longevity of a design by studying multiple load cycles to locate weak areas prone to failure

4. Simulating complex assemblies

- Preserve and leverage assembly models to study system behavior rather than a part-by-part analysis
- Use the right modeling/meshing/materials to arrive at the optimal result for assemblies

5. Leverage Industry recognized and trusted brand

- Add confidence in design-decisions by using an industry recognized solver
- Add value and build credibility in competitive bids by leveraging powerful simulations to demonstrate why your design is superior

Objection Handling

1. "We don't have time"/"We don't have experts"/"We build prototypes"/"Intuition or hand calculations suffice"

These are common responses to thwart attempts to change the status quo. However, these companies are likely to benefit the most with in-house simulation. Identify their product development hurdles and impact on profitability to help ease the conversation about the benefits of Simulation. Demonstrating the embedded workflows and ease-of-use will go a long way in helping them understand the benefits of Simulation.

2. "We get enough insights using Static tests/Part level analysis"

Most machines are moderate to complex assemblies involving a range of motion and often subjected to varied loads. Frequency, buckling, thermal and fatigue life are common considerations in product development that cannot be discounted or approximated in static testing. Emphasize that a full-featured solver is critical in avoiding machine failure.

3. "We already use SolidWorks Simulation"

SolidWorks Simulation is integrated nicely into SolidWorks, but lacks the firepower to solve robust contact problems in assemblies. It also falls short in non-linear capabilities, and its solver accuracy has been questioned. Push the accuracy, robustness and industry credibility of the Autodesk Nastran In-CAD solver, and emphasize the ability to standardize on a single CAD-embedded analysis platform across CAD products (especially in a mixed design tool environment).

4. **"We are using ANSYS DesignSpace"**

ANSYS DesignSpace is not an embedded solution. It is also an entry-level FEA product with limited capabilities. ANSYS often uses this as a stepping stone to selling high end solutions. To win against ANSYS DesignSpace, focus on pushing the whole range of analysis types we support, and the user friendly CAD-embedded workflow of Autodesk Nastran In-CAD.

User/Influencer Common Challenges and Solutions

Challenge	Solution
Need to simulate complex modular assemblies with varying geometry cross-sections	Autodesk Nastran In-CAD is fully interactive with the CAD model, and allows the user to choose the right meshing/modeling methods that is required to capture the full geometry and load response. It also helps represent assembly connections accurately, which can greatly impact the results.
Must design products that are durable and mitigate the risk of ECOs and warranty issues/recalls	With a wide-range of material models and operational load simulation tools, Autodesk Nastran In-CAD equips the user with the power to ensure that they can simulate field behavior as close to reality as possible. This ensures that a design that has been thoroughly tested before it is sent for production.
Need to simulate loads beyond static tests in order to accurately capture field behavior	Most machines go beyond static loads, and experience vibration (from motors), thermal loads (from heat sources), buckling (from compressive loads), and dynamic loads (time varying - like shock loads). With Autodesk Nastran In-CAD, a user can simulate all these and more without being limited by software.
Need to arrive at consistent, trustworthy results for simulations. Might also have a need to work across CAD platforms.	Autodesk Nastran In-CAD is powered by a robust, industry established and verified Nastran solver. This solver is heavily used in complex, life-sensitive simulations in industries like Aero. It is known for its accuracy, robustness and efficiency. Autodesk Nastran In-CAD is also uniquely built to offer an embedded workflow within both Inventor and SolidWorks, offering a chance to standardize on an analysis platform.

Decision Maker Common Challenges and Solutions

Challenge	Solution
Need to develop better products within a fixed timeline	Autodesk Nastran In-CAD works directly within the CAD environment and can be used in every stage of the design. Users can minimize errors and delays in product development, and reduce physical prototyping needs by ensuring that they are making the right design decisions early and often.
Must have a high win-rate in a global competitive bidding race	Given the competitive global market for machine design, it is important to have compelling differentiators that highlight a superior design. Using Autodesk Nastran In-CAD will boost in confidence in designs, establish credibility with the customer, and help win competitive bids.
Must increase profitability by reducing development time and recalls	In a highly competitive environment, the profit margins are small, and it is critical to minimize wasted manpower and resources. Autodesk Nastran In-CAD helps achieve high profitability by reducing the need for physical prototypes, and boosting confidence that the design will function for its expected lifespan.
Need to guarantee reliability in order to establish the brand as a credible and trusted manufacturer	Product quality is critical in building credibility around a brand. By running various simulations in Autodesk Nastran In-CAD, users can build reliable assemblies that function as desired in the field. This builds brand equity and awareness and establishes the manufacturer as a trusted provider in the industry.

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