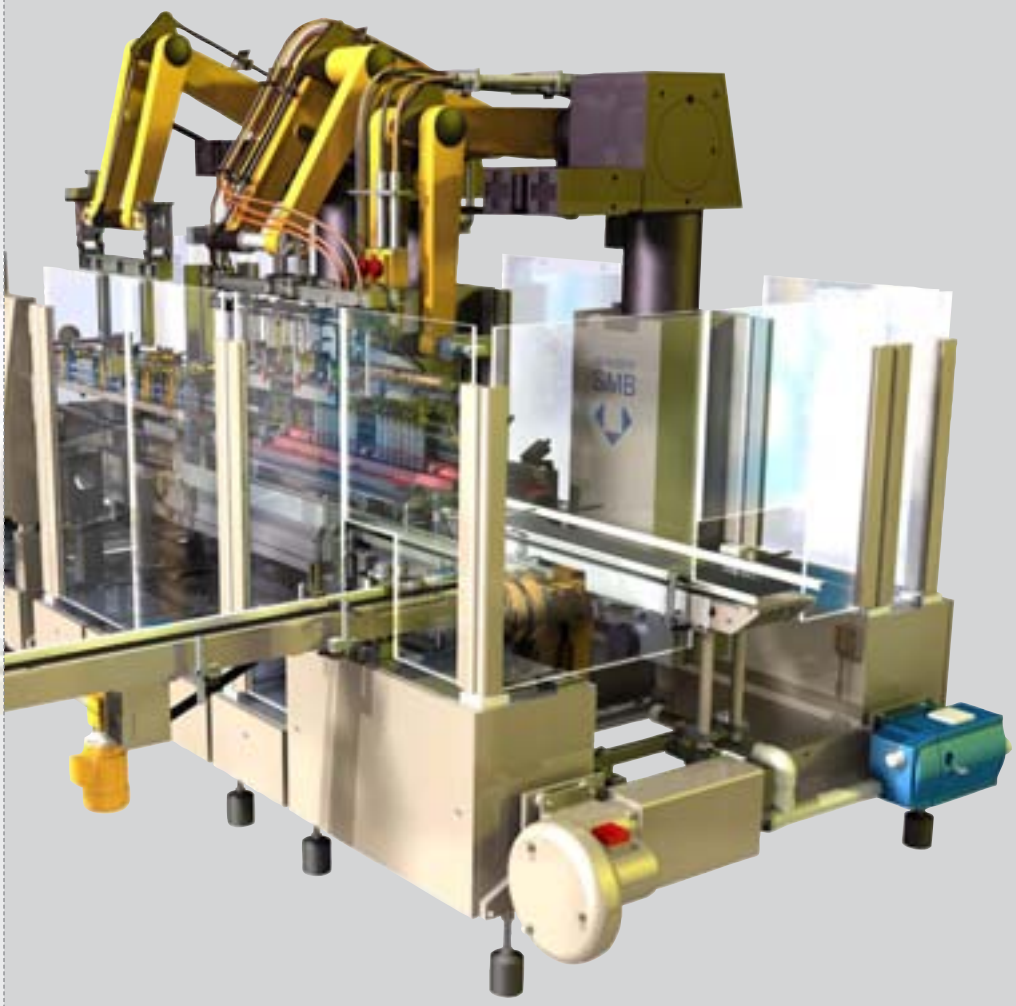
WHITE PAPER

Analysis Guide for Machine Designers

CONTENTS



COSMOS®

SolidWorks Corporation

SolidWorks

Analysis and simulation software is an indispensable tool in the development of largescale machinery. These tools allow the developer to evaluate designs early in the design cycle, determine causes of premature failures in the field, quickly explore designs changes aimed at reducing cost and weight, and determine the product's factor of safety. Use of analysis tools are of particular value to machine designers due to the size and complexity of the systems they are developing. Analysis tools can identify design issues that may elude a designer's review simply because of the dynamic nature of machinery's many moving parts.

Figure 1

FANUC Robotics utilized the COSMOSWorks add-on to SolidWorks to optimize designs. This combination made it easy to do analysis and to change dimensions of parts where required which allowed engineers to create better designs. FANUC claims that with COSMOSWorks it now only takes 15 minutes to analyze a robot's inner arm without simplification on a high end PC.

Analysis tools can identify design issues that may elude a designer's review simply because of the dynamic nature of machinery's many moving parts.

The unyielding demands upon machinery manufacturers by customers and the market to create systems that are cheaper, more reliable, and more productive necessitate that companies that wish to remain successful utilize all the tools available to them. These analysis tools reduce product development costs through a reduction of late engineering changes. They ensure products reach the market promptly, allowing the product to capture the largest piece of the market possible. Finally, it allows engineers to experiment with materials and designs that can result in products of minimal weight and cost. Analysis software enables engineers to simulate design performance and identify and address potential design problems before prototyping and production.

This guide describes the key design performance issues facing machine designers and manufacturers and identifies the benefits of using COSMOS analysis software in their product development cycle.

Analysis at the forefront of machine design product development

Regardless of the specific application machine designers are under pressure from their customers: increase reliability and longevity, be quicker to market with new, improved products, reduce product weight and cost, and increase productivity. Working in this type of environment, engineers have little time to produce multiple prototypes and use trial and error to gain a better understanding of the physical behavior of their designs. Yet, that information is vital for producing innovative, high-quality products.

Figure 2

Using COSMOSWorks, Fanuc's team of engineers can now take full advantage of the power of the solid modeler. The graphics packages convert stress numbers into something that can be easily seen, the solver is fast and because COSMOS™ is embedded in SolidWorks package, it helps improve productivity of Fanuc's development group.

Analysis tools help machine designers understand the physical behavior of their designs quickly without resorting to expensive prototypes and physical tests that extend the product design cycle. Analysis tools can substantially reduce the number of ECOs, missed deadlines due to redesigns late in the design cycle, and costly redesigns at manufacturing time. All of these markedly decrease development costs and time-to market. Further, these tools increase communication between design, sales, marketing, manufacturing and the customer through their easy to read and understand graphical results.

Analysis tools help machine designers understand the physical behavior of their designs quickly without resorting to expensive prototypes and physical tests that extend the product design cycle.

Application areas

- Production Equipment: Hallmark Cards, Food Production
- Industrial Robots and Robotic Systems: Design Optimization, Failure Analysis.
- Industrial Food Machinery
- Packaging Equipment.
- Electromechanical Systems: Heating [Process Control Systems?].
- Printed Circuit Boards: semiconductors, heat sinks, MEMS.
- Cooling Systems: fans, motors, air flows.
- Fluidic Systems: antennas, transmitters, switches.
- Automation Tooling
- Aerating machines, for beverages
- Bag opening, filling and closing machines
- Bottling machinery: washing, sterilizing, filling, capping, and labeling
- Bread wrapping machines
- Carton packing machines
- Label moisteners, industrial type
- Labeling machinery, industrial type
- Wrapping machines

Scope of analysis

- Design verification/validation: Will this design work? Will this design behave the way I think it will?
- Relative merit: Which of these candidate designs is the best? How can I weed out and eliminate poor-functioning designs?
- Proof of concept: Testing radical new concepts without producing prototypes.
- Durability and reliability: Fatigue/failure analysis, drop tests, shake simulations.

Tight integration with 3D CAD

COSMOS analysis software is tightly integrated with all major CAD systems and is directly integrated with the SolidWorks® modeling system, the standard for 3D design. This means that engineers can use COSMOS analysis software directly on the CAD model and do not need to remodel designs to take advantage of analysis technology.

Figure 3

Robert McAnany is a design engineer at Hallmark Cards who develops card-manufacturing machinery. Innovation and speed are essential in the design of the machines. For one particular project, McAnany spent a week doing design iterations of four critical components. "In that time, I looked at 18 separate designs. That investment in COSMOS software saved at least six weeks of trial and error in the shop, enough to pay back the cost of the software," he explains. What's more, the machine worked right the first time. "I didn't have time to do it wrong on this project," McAnany says.

"What if" studies

Using computational model and analysis software to perform "what if" evaluations saves time and money and can help to improve design performance.

A clear advantage of performing "virtual" testing using computer simulations over physical testing, beyond the cost and time savings, is the ability to quickly compare many designs incorporating different materials, part geometries, assembly configurations, subsystems, etc. Using analysis to conduct "what if" studies — what if I tried this material, or what if I used this type of mechanism — can help engineers identify the best material and mechanical design for a particular function. Using computational model and analysis software to perform "what if" evaluations saves time and money and can help to improve design performance. By coupling analysis studies with SolidWorks Configuration Management, the designer can quickly converge on the best-form design solution over many degrees of freedom.

Figure 4

Modular and custom air handlers are ideal products for analysis because they must be able to heat, cool, humidify and dehumidify air as well as filter particles. One of the Northeast's most innovative and responsive suppliers is Cambridgeport Air Systems. Shortly after installing COSMOSFloWorks, Cambridgeport started to see an impressive return-on-investment. COSMOSFloWorks analysis results replaced three physical prototypes, saving an estimated $5,000-6,000. It allowed them to bid on jobs that before were considered too complicated.

Powerful analysis types — static, motion, thermal, vibration, fluid-flow, nonlinear, electromagnetic

Machine designers must work with systems of amazing complexity and variability. The kinematics and dynamics all of the system's moving parts and their potential for interference requires a great amount of design effort. Thermal effects of the heat producing components upon the rest of the system's systems can be difficult to predict and design around. Vibration and other structural issues can lead to part failures, poor performance, and other operational issues. Companies that use analysis to address these issues at the design state develop a clear advantage over their competitors. COSMOS analysis software helps to ensure that these considerations are addressed early in the product development cycle, enabling manufacturers to accelerate time-tomarket and reduce development costs while producing higher quality products with fewer warranty issues. Using a range of analysis technologies, COSMOS software helps engineers to ensure that a product's behavior will be within design limits, reliable, and free of the risk of thermal, electromagnetic, or stress-induced failures.

Companies that use analysis to address these issues at the design state develop a clear advantage over their competitors.

Figure 5

Casa Herrera designs and manufactures machinery that processes flour and corn food products such as tortillas and corn chips. Using COSMOS in their design analysis, the critical forces of machine components such as the roller on a sheeter head can be calculated in 30 minutes. This complex analysis would have taken a senior engineer two weeks in the past.

- Static analysis is a tool that empowers the machine designer to avoid catastrophic immediate or long term failure modes and determine if re-design of one or more of the core elements is necessary. Designers can study the stresses or deflections in the device and compare it against allowable levels to predict failure. COSMOSWorks has the ability to analyze shells using SolidWorks surfaces and by extracting mid surfaces of thin walled structures, particularly useful in machines that incorporate sheet metal in their designs. Through static analysis, designers can optimize geometries, minimize weight and material usage, and determine the factor of safety built into each of their machines.

- Motion analysis is also extremely valuable in the development of machinery in that they are by their nature extremely complex, dynamic assemblies. Running motion analysis allows designers to perform "virtual testing" before manufacturing physical prototypes, saving time and money during the iterative design cycle. Changes prior to "cutting metal" are far cheaper and quicker to enact. Motion analysis allows the designer to learn more about the machinery in the concept phase and perform dynamic interference detection prior to building engineering models.

- Thermal analysis is critically important in machine design. Managing temperature, whether it's of printed circuit boards, mechanical devices, or of fluidic systems can be an important design challenge that an engineer must overcome. COSMOS analysis software can perform steady-state or transient thermal analysis on parts or assemblies. After meshing the design, the designer sets any relevant constraints, then sets power or heat flux conditions associated with a geometrical feature of the model. Because component material properties include thermal conductivity, coefficient of thermal expansion, and heat capacity, the designer gets a realistic prediction of temperature distributions under prescribed loads and operating conditions.

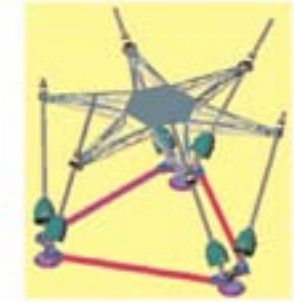


Figure 6

Pushcorp, Inc. manufactures end-of-arm robotic and automation tooling. Pushcorp chose SolidWorks and COSMOSWorks for their ease of use, tight integration with Windows, and extreme functionality. The sheet metal feature in SolidWorks also has the ability to integrate well with local shops. Furthermore, being able to use both COSMOSWorks and SolidWorks lets Pushcorp "get it right the first time."

- Vibration analysis is valuable in many types of machinery products. Many have motors, pumps, and other vibration sources that can adversely affect performance of surrounding electronic and mechanical devices. Optimal performance, with a minimal amount of adverse effects on these components, requires an understanding of the natural frequencies at which a component or assembly will vibrate and the impact of any stresses or deflections that may occur. Using COSMOS analysis software, an engineer can simulate the natural frequencies of a part or assembly and use this information to modify the design or materials used to avoid resonance and deflection in certain areas or improve performance. Random vibration analysis can also help engineers stiffen electrical systems that are designed to survive earthquakes and represent a more cost-effective approach than conducting physical shake tests. Analysis can be used to minimize frequency and vibration to minimize the perturbations' effects on the system performance.

Using COSMOS analysis software, an engineer can simulate the natural frequencies of a part or assembly

Figure 7

Neumag continuously improves the texture nozzle design - a process traditionally done thru trial-and-error, which is not optimal due to the high cost and the time it takes to produce the required prototypes. They realized that experimental data was no longer sufficient and creating prototypes and using external experts was too expensive. COSMOS FloWorks allowed Neumag to better understand their designs and better predict the effects of their design changes.

- Fluid-flow analysis has a number of applications in the machine design domain. Fluid flow properties play a large role in heat transfer analysis. Large machinery generally has large heat sources such as power supplies and motors that require active cooling. Convective and conjugative heat transfer are dependent on fluid flow properties. Fluidic systems such as hydraulics can also be modeled and their designs evaluated. Third, this analysis can be used in the design process of fluidic components such as nozzles, valvings, pump systems and lubrication systems. Whatever a manufacturer's analytical needs, COSMOSFloWorks™ offers high-powered computational flow dynamics (CFD) analysis for understanding the impact of fluid flow on temperature in electrical systems.

Large machinery generally has large heat sources such as power supplies and motors that require active cooling.

- Nonlinear analysis gives electronics and electrical product designers the ability to evaluate product performance within a complex, 3D-simulated environment, giving them a far more accurate determination of the different factors that may cause a device to fail. Nonlinear analysis tools are effective for analyzing static and dynamic problems with geometric and material nonlinearity, hyperelasticity, creep, thermo-plasticity and viscoelasticity. COSMOSM® nonlinear analysis software can also analyze nonlinear contact problems involving surface interactions of models with or without friction.

Figure 8

Break the rules of mechanical design? This is what COSMOSFloWorks software recently helped David Rachels and his engineering team accomplish while redesigning a cyclonic inertial separator for a major North American turbine engine manufacturer. The design challenge was to maximize the rotation of the air to increase efficiency and maintain the delta P below the customer specified limit. To discover how close they were to this objective, they took specific model combinations and analyzed them in COSMOSFloWorks . 27 variations were analyzed, including all of the axial points as well as the central point.

- Electromagnetic analysis software provides powerful electric field strength optimization techniques frequently used in large scale machine design. For example. interference between power sources and circuit boards can have ramifications that can adversely affect system performance. These analysis capabilities COSMOSEMS™ are also helpful for resolving electromagnetic interference and compatibility issues.

Assembly analysis

Large-scale assembly analysis is absolutely critical for machinery designers. Industrial machinery by its nature contains many complex subassemblies of many parts. As such, analysis on machine designs requires a wide range of attachment, interconnection, and encapsulation methods. Designers require that analysis run on their parts, subassemblies, and full assemblies. These assemblies can be affected by heat, pressure, vibration, impacts, and electromagnetic fields at all levels of the design.

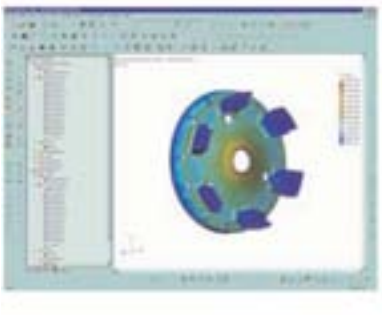


Figure 9

Speedgrip Chuck Inc. uses COSMOSWorks to check stresses in chucks. Speedgrip makes precision work holding devices known as chucks. These chucks hold parts and other objects while they're being manufactured. Speedgrip's chucks are used in production tools such as lathes and grinding, balancing, and welding machines.

COSMOS assembly gap/contact analysis allows you to simulate various real-life conditions for large machines.

COSMOS analysis software enables engineers to simulate all of these behaviors by allowing for the analysis of small or large CAD assemblies. The software allows engineers to assign different materials to different parts of the assembly and specify how the components will interact with each other. COSMOS assembly gap/contact analysis allows you to simulate various real-life conditions for large machines.

Many of what in the past have been physical tests on large machines can now be moved to computer simulations. Drop tests, to ensure that shipping does not damage the machinery, can be performed during the design phase and easier, less costly changes can be made prior to physical prototyping and manufacturing. Thermal analysis can ensure that no components within the system become overheated and can aid in designing appropriate heating and cooling systems within the machinery. Sources of vibration within system can be modeled and their effects on surrounding components studied. This allows for effective isolation systems to be developed early in the design cycle.

3D Visualization

COSMOS analysis tools enable analysis of machinery and large scale industrial products at the component, assembly, and system levels.

- 3D visualization provides a designer with a first check of design intent, proper operation, and aesthetics as the project develops.
- 3D CAD enables the designer to view a product design from all angles and examine the internal parts of the product throughout the design process. This gives designers a clear and accurate review of parts and assemblies early in the design cycle.
- 3D visualization reduces communication and fabrication errors, saving development time by more effectively conveying design information so that designers can find problems early in the design cycle. Designers can view the product from all sides and look inside by hiding the outer enclosure or other parts.
- 3D animations of simulations allow you to see how the machinery functions in the real world.
- Section plots allow you to see simulation results inside the part and not just on the surface.

Collaboration tools offer new ways for product designers to work more effectively with other members of the development team.

Figure 10

The Johnson Corporation provides advanced process control systems, rotary joints, syphon and heating systems and related components for fluid and heat transfer equipment that is used in process industries. In the optimization of a rotary joint and syphon assembly that is used in high-speed papermaking machines, COSMOSWorks allowed the Johnson engineers to analyze these parts and track more concepts in a shorter period of time with fewer design iterations. The result was an assembly that was stronger, lighter, and more durable, and it was developed in a fraction of the normal development time.

Design communication and collaboration tools

- Design collaboration has become an increasingly important part of the product development process, enabling designers to share designs easily with anyone, anywhere.
- Collaboration tools offer new ways for product designers to work more effectively with other members of the development team. The ability to share design resources over the Internet benefits all product designers, from independent consultants to engineers in large multinational corporations.
- COSMOS analysis tools allow designers to share analysis results in various formats such as:
  - HTML reports of analysis results
  - VRML files
  - AVI files
  - COSMOSWorks allows users to publish eDrawings for analysis results.

SolidWorks Corporation
300 Baker Avenue
Concord, MA 01742 USA
Phone: 1 800 693 9000
Outside the US: +1 978 371 5011
Fax: +1 978 371 7303
Email: info@solidworks.com

SolidWorks Europe
Phone: +33 4 42 15 03 85
Fax: +33 4 42 75 31 94
Email: infoeurope@solidworks.com

SolidWorks Asia/Pacific
Phone: +65 6866 3885
Fax: +65 6866 3838
Email: infoap@solidworks.com

SolidWorks Latin America
Phone: +55 11 3818 0980
Fax: +55 11 3818 0977
Email: infola@solidworks.com

COSMOS
3000 Ocean Park Boulevard, Suite 2001
Santa Monica CA 90405
Phone: 1 800 469 7287
Outside the US: +1 310 309 2800
Fax: +1 310 207 2774
Email: info@srac.com

COSMOS®

For additional information about COSMOS products, check out the COSMOS website http://www.cosmosm.com.

SolidWorks

SolidWorks Corporation