Do the Math:

Engineering Calculation Software Essential for Predictive Engineering

PTC®

Maximize the speed, efficiency and quality of product development by making the most of predictive engineering.

Whether you're dealing with the stock market, the weather – or that elusive condition known as customer behavior, having an ability to accurately predict the future can lead to success in nearly any endeavor. This is especially true for CAD engineers and product development organizations.

Numerous CAD tools are aimed at just that: predicting the outcome of the product before it moves through design and manufacturing and into the hands of the customer. Software for structural analysis, mechanism dynamics, and virtual prototyping are examples.

Even the ability to reuse existing CAD models for new product development can be a valuable predictive resource, since using a predesigned part or platform helps predict the behavior of some aspects of the new product.

No doubt, the better the CAD designer can predict the fit, feel, function, cost and reliability of the finished product, the better the chances of delivering a competitive product on time and within budget. CAD engineers and product development companies know this. What they may not realize, however, is that one often overlooked process – automating engineering calculations – can be every bit as important as using analysis tools, virtual prototypes, and other predictive resources. Here's why.

Product development professionals are able to predict the form, fit and function of their 3D CAD model designs using today's powerful engineering calculation software, such as Mathcad® from PTC.

Old habits die hard

CAD software has evolved to make the fundamental mathematics of product design transparent to design engineers. However, CAD design also requires frequent ad hoc calculations for everything from performing unit conversions to testing probability models. These vital calculations were, and often still are, performed manually with slide rules or calculators.

In organizations where product development processes are simple and straightforward, and market demands are relatively obvious, manual calculations may still suffice. But today's typical product development company faces ever-more-challenging markets, tougher and quicker competitors, and more demanding supply chains, sales channels, and customer-support responsibilities. New-product cycles have dropped from six months to three months. New competitors are appearing from increasingly remote locations. Production costs are climbing, and budgets are tightening. Performing engineering calculations manually – or even using spreadsheets – is not keeping up.

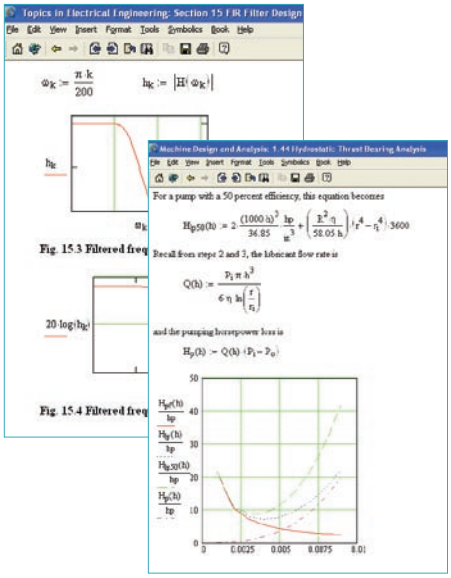
For CAD designers, automating the process of performing ad hoc calculations is now essential because it enables you to automatically document the specific intent of the original designer, in a form that's both traceable, testable and most important, reusable. Also, engineering calculation software can perform complex calculations in a fraction of the time of traditional methods. It can save time, and reduce or prevent errors by the CAD designer, and help the organization deliver better quality products in shorter timeframes.

Putting it to use

As an example, consider the CAD designer who calls up the current-generation product model from the CAD library when tasked with building a shock absorber. Thanks to engineering calculation software, the new designer sees the detailed assumptions and decisions of the original designer. The calculations might show, for instance, that the shock absorber was originally intended for a certain-sized axle, and then later changed to fit a different-sized axle. Knowing this, the designer can determine where the new design might be affected by any compromises (for example, in axle clearance or vibration threshold) that the original designer had to make.

This information helps the new designer save considerable time and minimize cost by reusing the early generation design, while at the same time keeping product quality high.

Automating the capture of engineering calculations helps in other ways. For instance, the CAD designer can do a preliminary analysis – this requires calculations that would be too difficult or time-consuming to do manually – to predict behavior of a component or material before it goes for a complete analysis. From this, the designer can tighten the assumptions that will be passed to the analysis software, which can save the time and cost of unnecessary testing.



The worksheets in PTC's Mathcad engineering calculations software combine natural math notation and diagrams, enabling engineers to fully document a calculation.

Where it fits

Engineering calculations are proving to be useful, and often necessary, at all points along the design cycle, from concept to manufacturing. Here are some examples:

Concept planning

Here is where early sizing, or early validation, can save time by answering top-level questions about basic form and fit. To build a refrigeration unit, for instance, the CAD designer might use engineering calculation software to see if the piping will fit within the refrigerator casing. Likewise, a cell phone designer might check the basic fit of the printed circuit board, the speaker, or the microphone.

Requirements definition

This often involves a project-team meeting that includes the design engineer, Marketing or business development people, project manager, and others – and may even bring in the customer via video conference. Here's where the engineer can use engineering calculation software for "scratchpad math," to explore alternatives that might come up in the meeting.

Here, doing the math on-the-fly lets the engineer take advantage of the spontaneity of the meeting members to raise and resolve important issues. And because these important calculations are saved for later review, the designer can proceed with confidence knowing that everyone involved fully understands both the issues and the agreed-upon solutions.

Design modeling

The design engineer begins this phase by looking for previous parts or assemblies that can be reused. Again, in building a shock absorber, the designer might retrieve the current generation model from the CAD library, along with any axle or other assemblies that make use of that shock absorber. If the files contain engineering calculations, the designer will likely save valuable time by gaining a precise understanding of the conditions – and the compromises – surrounding the original designer's work.

Analysis

Engineering calculation software can be very useful for pre- and post-processing support of industry standard finite element analysis (FEA) and other tools. As a pre-processor, engineering calculation software helps with basic sizing and testing of top-level assumptions, and thus can sharpen the focus of the problem that's presented to the analysis application. This insight enables the engineer to avoid wasting time on a misdirected analysis project; a full FEA simulation can take several hours, so it's beneficial to make the analysis as meaningful as possible.

As a tool for post-processing, engineering calculation software helps the designer sanity-check the analysis results by running simplified tests that will deliver numbers in the same range as the FEA outputs. For instance, to sanity-check the shock absorber's stress test, the designer can use engineering calculation software to place a virtual box around the shock, and then put a load on the box. True, engineering calculation software can't perform the same deformation testing as the FEA tool, yet it does deliver results via the applied box that should be within range of the FEA tests.

Quality Assurance and Quality Control

Before turning the model over to Manufacturing, the designer can use engineering calculation software to check that the product will meet manufacturing specifications. These could range from tolerance requirements to safety and/or Six Sigma parameters.

Again, the software won't perform extensive testing, but in a matter of seconds it can answer simple conditional statements: Does the model meet this safety requirement? Does it meet that Six Sigma requirement? Chances are, the model will pass these simple tests, but if it raises a flag, the designer – and the entire organization – will be far better off than if the model had been passed directly to Manufacturing, where solving even a small problem can quickly become very costly and may jeopardize delivery schedules.

PTC: Vendor Perspective

PTC's engineering calculation software, Mathcad®, is very popular with product development organizations of all sizes and industries because it combines robust functions with a unique, easy-to-use whiteboard interface. As well, it features the power of natural-math notation.

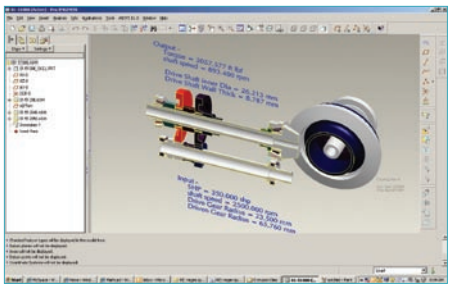
Design engineers use Mathcad as an electronic whiteboard, writing formulas and text anywhere on the screen. Mathcad checks for calculation errors, performs unit conversions, and then, when asked, delivers powerful computations that include everything from high-end numerics to live symbolics, vector and matrix handling, and differential-equation solving.

Mathcad offers many other capabilities that are very useful to designers and engineers. It can display in a number of math formats, offers a variety of built-in operators, performs IEEE-adherent math, and features a range of graphing and visualization functions. It also maintains a comprehensive suite of specialized libraries for Mechanical, Electrical, and Civil Engineering applications, and it offers extensions for data analysis, signal processing, and other disciplines.

Using a file format based on XML standards, Mathcad is compatible with a range of CAD and CAE applications, as well as with other engineering calculation software and ODBC (Open DataBase Connectivity)– compliant databases.

When used with 3D CAD tools, Mathcad can employ bi-directional integration to map Mathcad values to parameters in the CAD model, and to automatically update the calculations if the parameters change.

Most importantly, Mathcad is simple to use, and doesn't hide calculations from the designer's view, like other types of calculation software based on spreadsheets or "black-box" processors. Spreadsheets can be difficult to read, especially where complex equations are concerned. And black-box software does produce a result, the software itself may not let the designer check the actual calculations, thus risking a loss of insight and possibly confidence in the process.



Bi-directional integration allows dimensions and parameters from the Pro/ENGINEER® model to drive Mathcad analysis. Results from these calculations return to Pro/ENGINEER to update the geometry of the model.

Making the Most of Predictive Engineering

In every step of the product development process, Mathcad helps all product stakeholders – the designer, the product development team, test engineers, and manufacturing personnel – to gain an early understanding of how the model will ultimately behave – how it will fit and operate when it's eventually manufactured and delivered.

This pays substantial dividends in a number of ways. It promotes design reuse and reduces scrap waste by producing products that are faithful to their designer's intent and targeted closely to their intended markets. It can speed product development time by cutting out wasteful designs, redundant tests or other processes. It can reveal and help solve problems early in the product design cycle, so they don't become disruptive and costly later in the cycle. And, it can help to establish a continuous feedback loop for design intent and knowledge transfer that will benefit both future designers and future design projects.

Adept Scientific plc
Amor Way, Letchworth,
Herts, SG6 1ZA, UK
T: 01462 480055 F: 01462 480213
Email: info@adeptscience.co.uk
www.adeptscience.co.uk

Adept Scientific A/S
Produktionsvej 26,
DK-2600 Glostrup, Denmark
T: +45 48 25 17 77 F: +45 48 24 08 47
Email: info@adeptscientific.dk
www.adeptscientific.dk

Adept Scientific GmbH
Hamburger Allee 26-28,
60486 Frankfurt, Germany
T: +49 (0)69 970 841 18 F: +49 (0)69 970 841 41
Email: info@adeptscience.de
www.adeptscience.de

Adept Scientific Inc.
7909 Charleston Ct.,
Bethesda, MD 20817, USA
T: +1 800 724 8380
F: +1 240 465 0422
Email: info@adeptscience.com
www.adeptscience.com

www.adeptscience.com

Copyright 2008, Parametric Technology Corporation (PTC). All rights reserved. Information described herein is furnished for informational use only, is subject to change without notice, and should not be construed as a guarantee, commitment, condition or offer by PTC. PTC, Pro/ENGINEER, Mathcad, and all PTC product names and logos are trademarks or registered trademarks of PTC and/or its subsidiaries in the United States and in other countries. All other product or company names are property of their respective owners.

3958-SMB-Mathcad-1008