White Paper

Parametric Analysis: The Key to Rapid, Robust Design

Parametric studies can drive significant time and costs out of the development process — while still ensuring design robustness and ultimate product integrity.

As business pressures continue to increase, parametric design studies are becoming a competitive imperative. Those businesses that adopt this concept will be leaders, while others will be followers.

Today's business world is characterized by an increased demand for innovation, shorter product life cycles, and incredible pressures to launch new products quickly. At the same time, product development teams face cost-cutting challenges. Even in the face of these pressures, no business can afford to sacrifice robust design. To fulfill the ultimate customer promise, products must perform as expected in the real world, every day and in every situation.

Engineering simulation, with its ability to design, prototype and test products in the low-risk virtual world, has provided many companies with a fast, cost-effective way to create robust product designs [1].

However, not every company is leveraging the full power of engineering simulation tools. These advanced solutions have an incredible capability to support parametric analyses — in which certain design parameters are modified and the effect of these variations is studied across the entire design in an iterative process. By understanding the impact of each small change, the speed of the product development process can be increased by a factor of 10.

Why aren't more companies embracing the speed and power of this advanced analysis? Engineering teams may claim they lack the time, computational power or advanced software tools needed to create the necessary design environment. Whatever the excuse, one clear fact is emerging: As business pressures continue to increase, parametric design studies are becoming a competitive imperative. Those businesses that adopt this concept will be leaders, while others will be followers.

Getting It Right the First Time

Jim Cashman, CEO of ANSYS, recently noted, "The cost of being wrong has never been so great." Throughout 2010 and 2011, global headlines were dominated by product failures and recalls that not only cost billions of dollars — but also caused irreparable damage to some well-known consumer brand names. Even if your product integrity issues don't make worldwide news, they still increase warranty costs and impact customer confidence. Quality, reliability and robust design are critical to fulfilling your essential promises to customers.

An Aberdeen study in 2008 found that the impact of engineering simulation can be tremendous: Companies leveraging engineering simulations were able to reduce the number of prototypes by 37 percent — delivering average cost reductions of $332,673 and time reductions of 118 days for complex products.

For companies that do consistently deliver high-quality, innovative products via a short development cycle, the rewards can be tremendous. “The value of being right has never been so great, either,” added Cashman. A recent Aberdeen study of 704 companies using computational fluid dynamics (CFD) simulation demonstrated the high value that leading companies place on “getting it right the first time.” Among the top 20 percent of study participants who were deemed “best in class” by Aberdeen, these companies showed a much higher propensity to apply a strategy focused on getting design right the first time (47 percent versus 39 percent for all others) [2].

These best-in-class companies recognize a simple truth: If you introduce a product innovation that is not optimized, many times you do not get a second chance. While you are perfecting your design, a smart business across the road — or on the other side of the world — will quickly steal market share away from you.

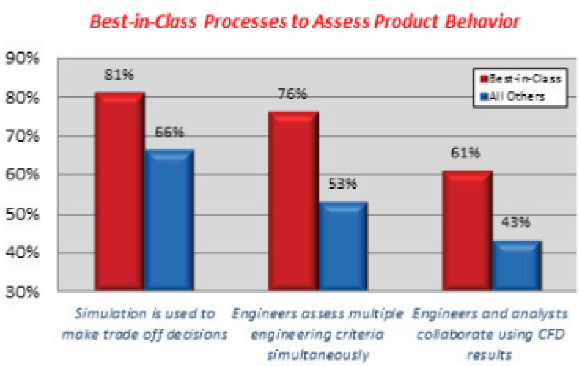
In today’s challenging competitive landscape, it is not enough to release an innovative, robust design quickly. That design also has to represent the best-possible solution, the very first time. Engineering simulation has helped businesses in every industry meet that challenge, by allowing design, prototyping and testing to occur in a virtual environment. The result is a high degree of innovation, since simulation through in-depth investigation reduces the risk associated with innovative product introduction.

“Technologies such as simulation increase the number of breakthroughs by trying out a greater number of diverse ideas. Computer simulation doesn’t simply replace physical prototypes as a cost-saving measure; it introduces an entirely different way of experimenting that invites innovation,” noted Stefan Thomke, professor of technology and operations management at Harvard Business School [3].

Parametric Analysis: High Speed, High Integrity

Not only are best-in-class businesses using engineering simulation to get their designs right, they are using advanced tools to combine an impeccable degree of product quality with the speed demanded by today’s business climate.

By varying model parameters via simulation, best-in-class engineering teams can quickly make the highest-impact design trade-offs that maximize overall product quality and performance, as well as investigate multiple design criteria simultaneously. As Thomke explained, via this type of analysis “many design possibilities can be explored in real time ... in rapid iterations.”



Processes implemented by the best-in-class companies to support their ability to get it right the first time

"[Parametric investigation] makes it possible to quickly evaluate hundreds of designs in batch processes to explore the complete design space so that we know we have the best possible design," noted Ken Karbon, staff engineer at General Motors [4].

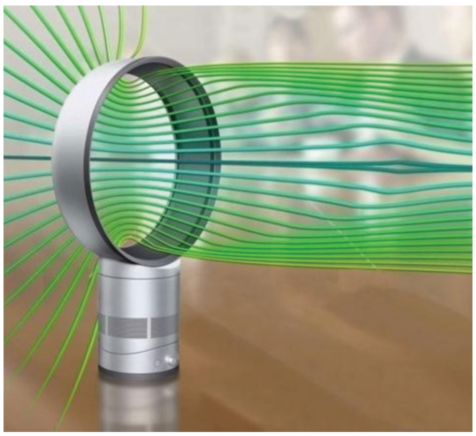
As the Aberdeen finding below demonstrates, best-in-class companies are significantly more likely to use simulation to make design trade-offs than other companies (81 percent versus 66 percent). Leaders also use simulation to assess multiple design criteria simultaneously at a much higher rate than other businesses (76 percent versus 53 percent) [2].

Many companies are already using advanced simulation tools in a strategic manner — creating high-fidelity models by identifying the right combination of geometric meshing, numerics and calculation schemes to obtain reliable and accurate results.

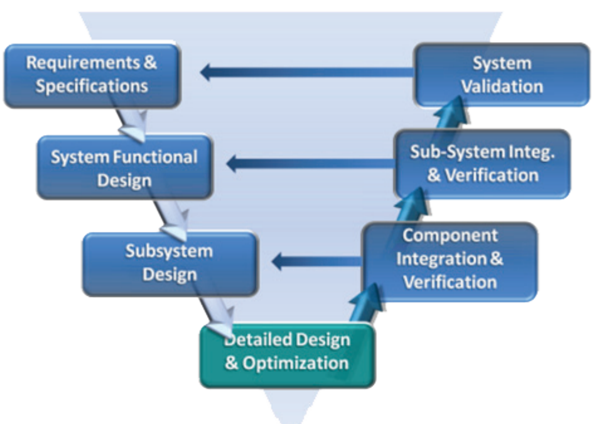
By adding the capability to vary existing parameters of these complex models – including materials properties, operating conditions and even geometries — these same engineering teams can rapidly quantify the impact of any modified parameter on the product's overall behavior and functionality. Many simulations users are keen to solve the challenge of a complex model, but then subsequently miss the full exploitation of their hard work by incorporating a parametric component.

In addition to adding speed, this type of investigation also supports cost-effective robust design. Engineers can easily evaluate the best possible designs against a much greater range of real-world scenarios than would be possible through physical prototyping alone. In some cases, they can also identify critical areas that could jeopardize product integrity — and that require more specific validation or help the engineering team understand which parameters really matter. This improves the ability of engineering teams to define cost-effective and targeted design of experiments for final physical testing.

Parametric analysis has the power to change the character of an entire engineering team, making its work even more impactful. "The ease of using simulation tools has helped transform our organization from a test-centric culture to an analysis-centric culture," said Bob Tickel, director of analysis at Cummins [5]. This cultural change supports the idea of "getting it right the first time" and ensures that product innovations will perform as expected when they are launched into the marketplace.



For the new bladeless fan, Dyson engineers developed a basic design concept in which air is drawn into the base of the unit by an impeller, accelerated through an annular aperture and then passed over an airfoil-shaped ramp that channels its direction.



Engineering amplification requires an organization to systematically adopt simulation at each stage of the smart product system design model (V Shape).

A Case In Point: Dyson

Dyson is known for revolutionizing common household products like the vacuum cleaner. It's no surprise that this company is also characterized by an innovative, best-in-class engineering process. The Dyson team routinely uses parametric analysis to bring its game-changing products to market rapidly, while also ensuring the utmost degree of product integrity.

In designing its groundbreaking Dyson Air Multiplier™ bladeless household fan, the Dyson engineering team faced the challenge of developing and optimizing the design of an original new product, without the benefit of previous experience with this type of design.

To complement their experimental testing and minimize development time, Dyson's engineers used CFD simulation software and a parameter-based approach to evaluate up to 10 different designs per day [6].

"Over the course of the design process, Dyson's engineers steadily improved the performance of the fan to the point that the final design has an amplification ratio of 15 to one, a 2.5-fold improvement over the six-to-one ratio of the original concept design," said Richard Mason, research, design and development manager at Dyson. "The team investigated 200 different design iterations using simulation, which was 10 times the number that would have been possible had physical prototyping been the primary design tool. Physical testing was used to validate the final design, and the results correlated well with the simulation analysis."

Making Parametric Analysis "Business as Usual"

As Dyson and other market leaders have demonstrated, parametric design investigations have an unmatched capability to accelerate the product development process, while still protecting product integrity.

However, while the need for a systematic use of engineering simulation early in the design process is a requirement today, varying model parameters for what-if analyses, goal-driven optimization and trade-off decision making is still only leveraged by leading companies.

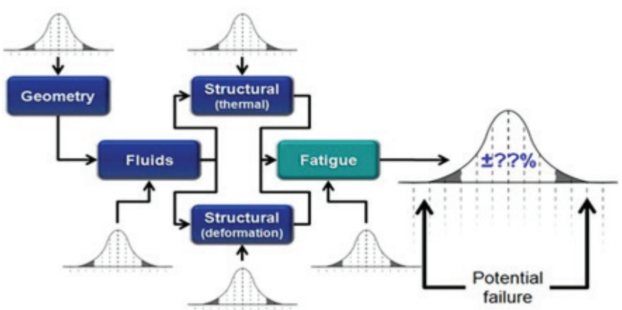
Just as early, systematic use of engineering simulation is now viewed as "business as usual" by industry leaders, a comprehensive parameter-based investigation should become mandatory in any design document. The project manager should make sure that important design parameters have been explicitly identified, and that their possible impacts on product functionality have been investigated and quantified.

Challenging decisions and assessing trade-offs through variations of parameters should be made at every step of the design process — not just after a complete virtual prototype has been achieved. Every single design decision may benefit from slight modifications that produce better quality, environmental benefits or cost savings that do not compromise overall product integrity.

Accomplished in a parametric manner, virtual testing can now be seamlessly integrated at the core of the design process, without slowing the process down. Design modifications can be achieved in the early stages, when there is more flexibility and fewer negative consequences. From the design of complex systems to individual components, parametric investigation has the power to change the entire product development process if it is embraced as simply a new way of doing business.

Preparing for a New Future

A number of important developments are making parametric analysis more feasible and achievable for the typical engineering organization. Processing speed and memory capabilities have been historic obstacles to the widespread use of this kind of analysis. However, with the democratization of large-scale multicore and multiprocessor computers, the necessary technology infrastructure now exists to implement this winning strategy. Today, the average engineering organization has access to the high-performance computing (HPC) environment needed to engage in design investigations based on varying parameters.



Including probabilistic variation of dimension, materials properties and operating condition is the next step that will allow product development organizations to reduce safety margin without compromising product integrity.

In addition, simulation software has made a number of rapid advances that support the growth of parametric analyses. While there is still a probabilistic nature associated with every parameter-based study — because of the unavoidable natural variations of geometries, material properties or operating condition—continued software improvements will soon be able to deliver tighter tolerances and advanced probabilistic descriptions of expected product behavior, as well as risk of failure predictions.

Historically, standard software licensing agreements made parametric analysis cost-prohibitive, as a large number of licenses may have been required to run what, in fact, represents a single investigation. As the leader in engineering simulation, ANSYS has addressed this challenge with effective licensing solutions that make it cost-effective and feasible for any business to accomplish large-scale variations of their design parameters.

When Simulation-Driven Product Development was first introduced, there was a huge performance gap between the leaders who quickly adopted this practice and the followers who favored a wait-and-see attitude. The leaders were able to quickly and cost-effectively launch innovative new products, with a high degree of confidence in their results. The followers lost market share and profits as they remained entrenched in their old ways of doing business.

As the global engineering community systematically adopts parametric analysis — supported by favorable technology developments and licensing agreements — we expect to see the same type of performance gap between the early adopters and companies who are more hesitant to embrace this new future.

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