Successful Virtual Food Processing

Thierry Marchal
ANSYS, Inc.
Industry Director

Abstract

Today's economic pressures are forcing organizations to innovate more in a faster time frame and to deliver robust and sustainable solutions from the first product release while keeping costs down. To succeed at these objectives, leading world-class companies are adopting engineering simulation to design, optimize, manufacture and test new products in the virtual, digital world before committing to production. This virtual approach — which was used initially for aerospace applications in which failures are not acceptable and physical tests are not always possible — has quickly spread across other industries, such as automotive, energy, electronics and now even healthcare, consumer products, and food processing. Numerous business studies confirm that engineering simulation adoption is leading to pervasive simulation — a world in which no new product design will be introduced without extensive numerical modeling to optimize and test it.

The increasing competitive and regulatory pressures in the food and beverage industry over the last decade hassled leading companies to take advantage of this powerful simulation paradigm. The virtual approach is being used to optimize manufacturing processes, improve existing designs and, now, develop completely new products faster and cheaper with more innovative features and more robust characteristics than any previous ones. ANSYS, Inc., an engineering simulation market leader, is fueling and driving this technological revolution. Engineering simulation tools and processes enable engineers worldwide to quickly realize product solutions that address emerging challenges, including sustainability, safety, energy, access to medical care and, in short, global prosperity and improvement of the human condition.

Engineering Simulation in Everyday Situations

Over the last 10 years, the industrial landscape has completely changed: reliable technologies fell short on market demand; consumers expectations continuously increase in both size and complexity, Fortune 500 leaders have flickered because of lack of product integrity for some flagship products; strong competition is now coming from emerging countries.

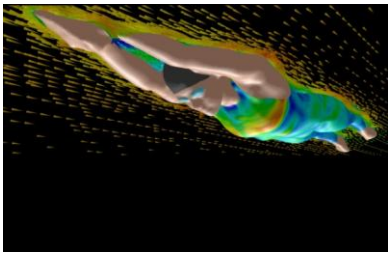
At the same time, the news media regularly reported on amazing technological challenges that engineers in pioneer companies around the world have addressed in the aerospace, automotive, civil engineering, energy and life science areas, among others. In parallel, product developers in all corners of the globe are increasingly adopting engineering simulation, which is used to predict the behavior of any product, existing ones as well as future solutions, under any possible circumstance by modeling the product in the virtual world. Initially developed for rocket science research a few decades ago but

progressively migrating toward industrial design, this digital prototyping approach has now penetrated all major industries and is spreading step by step into the manufacturing world.

As these two occurrences ran concurrently, it was no surprise to see food and beverage companies initiatives and engineering simulation converge, joining forces to build an innovative future. The results of this successful collaboration are already visible today in food processing — as well as in everyday life everywhere else in every industry. Even though engineering simulation is not a "household word," it is extensively used for a huge number of common problems and well-known applications. Listed below are some significant examples.

Best-in-Class Swimsuit

Inspired by the shark's skin and speed, some researchers have modeled details of the predator's skin and how flow behaves in its proximity. Simulation revealed micro flow patterns that can significantly impact resistance to motion underwater. Translating this approach to a virtual swimsuit on a virtual swimmer confirmed the positive impact an advanced swimsuit could have on the swimmer's performance. At the Beijing Olympics, sporting equipment contributed to some amazing performances, demonstrating that engineers can quickly learn from Mother Nature when they use tools that model it in a reliable way



Plastic Soda Bottles

Every day around the world, we consume 200 million water and soda plastic (PET) bottles! This represents more than 10,000 tons of PET discarded into the environment every year. One careful investigation using engineering simulation has allowed packaging engineers to test different shapes and adjust manufacturing processes, significantly reducing bottle weight **without** impacting its resistance to shock and dropping. As a result, we can save the planet from 10 percent of current plastic waste, reduce manufacturing costs and consume less raw material, while a price premium can be requested for this environment-friendly packaging.

Tasteful bread

If designing a laboratory device for bread dough is a challenge, the scale up of this device to production level is not a trivial task. Boosting the production rate by several orders of magnitude cannot be simplified to a linear scale up of the screw as important parameters as solubility, expansion index, and other quality attributes such as texture and mouth feel would be impacted in a non-uniform way. In fact, similar amount of dissipated mechanical energy in the device suggests similar extent of molecular breakdown or degradation the material undergoes during the extrusion process, hence similar taste for the consumer. Adjusting food production device through virtual

prototyping ensures that a production rate can be achieved quickly without compromising food quality and consumer satisfaction.

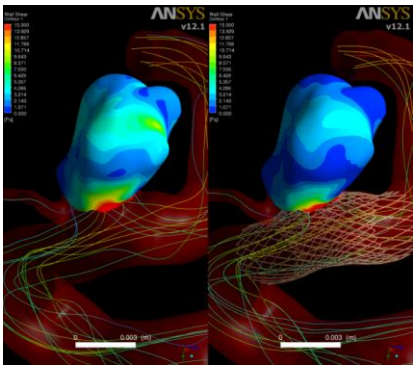
Life-Saving Electronic Devices

Implantable defibrillators have saved countless lives, and the new generation of these devices will do even more for patients. In the event of a heart attack, a modern defibrillator can simultaneously send a pulse to "reset" the heart while automatically transmitting a message to the healthcare team stating that the patient has experienced a major cardiac problem before even he or she knows it. Signal interference, a common challenge for electronic devices, can lead to dramatic consequences. Engineering simulation of electronic devices ensures that signal integrity, and in this application the patient's life, is not endangered. Wireless devices use rechargeable batteries, so repeated surgery is no longer needed; but it is now crucial that the recharging process is designed so it doesn't induce inconvenience or injury. Consider this case application: If battery recharge results in local heating, virtual prototyping helps to minimize it, making the patient safer and more comfortable.

Resistance to Earthquake

Despite their rarity, disasters such as devastating earthquakes and tsunamis do happen. In case of such events, commercial buildings as well as important energy and industrial facilities must survive the blow. Virtual simulation can predict a structure's exact behavior in the wake of tremors. If the facility fails virtually, parametric numerical simulation can suggest modifications that would ensure its integrity. Catastrophic disasters can be virtually modeled via engineering simulation, ensuring that a product's final design will successfully survive any real-world event.

Cerebral Aneurysm



A cerebral aneurysm, the ballooning of an artery in the brain, could be life threatening if it ruptures. While minimally invasive solutions exist — such as coiling and stenting — they are not risk free; therefore, they should not be considered if the risk of rupture is minimal. Currently, surgeons are making decisions based on aneurysm morphology, in which the healthcare team assesses the risk of rupture driven by hemodynamics, or blood flow. Using a patient's head scan, researchers extract patient-specific aneurysm geometry and model the exact blood flow. The process results in providing the surgeon with far more information, such as peak pressure, blood flux at the neck, wall shear stress — valuable data that can assist in making the right treatment decision. This experimental approach is currently being tested by a number of hospitals.

40 Years of Success Stories from NASA to Pervasive Simulation for Design and Production

40 years ago, engineering simulation emerged out of the need to understand processes in which physical measurement was impossible (nuclear industry, structural analysis) or full-scale preliminary tests were not feasible (aerospace, computational fluid dynamic or CFD). Leading industries (aerospace, automotive, energy, chemicals) and pioneering companies quickly came to realize the potential benefit of virtual investigations. The first engineering simulation codes were commercialized in the early 1970s.

Rapidly increasing hardware performance quickly unleashed the magnitude of simulations and design of experiments that could be performed. The popularity of numerical simulation in both the academic and industrial worlds resulted in an explosion of research to develop reliable and robust models able to properly and accurately predict the behavior of ever more complex structures. This trend initially was constrained to advanced fluid, structural or electromagnetic single-physics models. The market was quick to perceive the value of combining different physics into single models, just as reality encompasses multiple domains (multiphysics).

Multiprocessor and, soon, multicore computers opened the door to parametric simulation (design of experiment or DoE) and optimization, empowering designers to go beyond prediction of complex system behavior. Simulation became a tool used to test future solutions subject to any number of scenarios that could be experienced during a product's lifecycle, a technology that could systematically explore a range of solutions to identify the best one. Engineering simulation moved far beyond research to development and, eventually, production and manufacturing

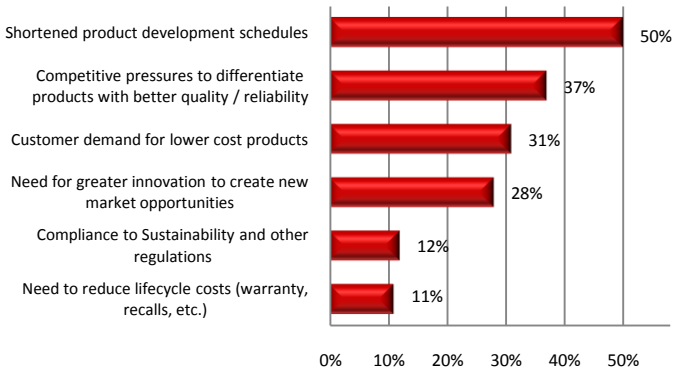
While the various industries and companies have not acquired the same computational maturity, they are all following the same path of progressively adopting simulation to model components or entire systems, to challenge existing solutions via what-if scenarios, to virtually optimize a process before deploying it across the company.

With the increasing power of high-performance computing (HPC), designers are embarking on including the probabilistic nature of materials and processes. Material properties are never the same, but they vary slightly around an average value. The same observations apply to geometry and operating conditions as well. Although these small variations may sound insignificant, the combination of them can lead to dramatic consequences. Thus was born the need for design for Six Sigma (DFSS). Modeling appears as the only serious option in combining an optimized solution with a probabilistic approach in what literature refers to as robust design optimization (RDO), the new frontier and an important objective.

Strategic Business Impact

As illustrated by a recent market survey done by the ABERDEEN Group (May 2011), the current key business drivers for most companies are time to market, quality, cost, innovation and sustainability (in

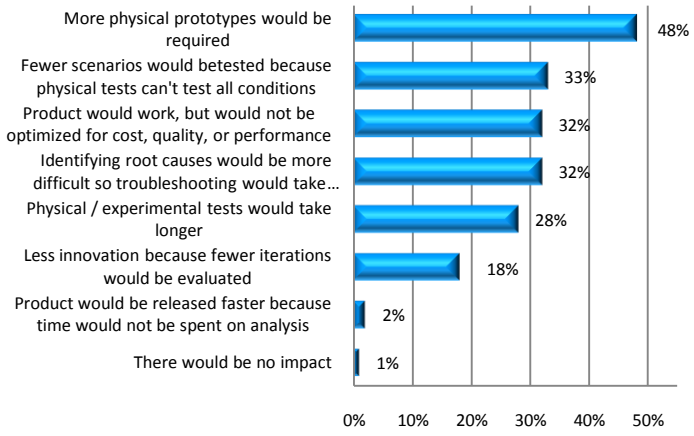
Industry Drivers



order of relevance). Depending upon the macro-economic situation, the relative importance may change: For example, cost to market was the primary driver 18 months ago. But time to market remains a significant concern whether the company enjoys a favorable situation or suffers during difficult times.

Similar investigations conducted among those involved with simulation clearly state that the immediate impact of **not** using engineering simulation is an immediate increase in the number of physical prototypes and the *de facto* increase of time and cost to market. Another obvious impact is the lack of robustness of new solutions or that solutions will not be optimized the first time.

Currently, 97 percent of *Fortune* 100 companies and a very large fraction of the largest global organizations are extensively using simulation. One might interpret this as full market penetration, as banks and retailers — which are quite unlikely to use the technology — are considered part of these scorecards. In reality, the market is far from saturated, and growth is accelerating in two directions. Market penetration is spreading across mid-size and small companies as simulation becomes more accessible and perceived as an important part of their business processes. At the same time, large companies that already employ simulation continually increase the ***pervasive*** nature of simulation by making it more systematic, more parametric and better integrated in their processes.



*Impact of **NOT** using engineering simulation*

As a consequence, no new airplane, car, nuclear or chemical facility, turbine, or engine is currently released without extensive numerical modeling during both the design stage and the production phase. As simulation becomes more widespread, it is expected that within a decade every major industrial product will benefit from digital investigation during its design, manufacturing and testing phase.

Food and Beverage Adoption

Food and Beverage companies are undoubtedly dealing with complex products and raw materials, making any modeling approach more delicate than for any other industry. Yet, it appears obvious that this sector is increasingly facing the same market pressures than others in terms of innovation, quality, safety, cost and even sustainability. Furthermore, food being the most essential

element of our everyday life, product integrity failure can very quickly ruin both the reputation and business of any organization as once again illustrated by the European news: this industry possesses all the necessary ingredients to beg for any technology advancement able to minimize the potential risk experienced by the consumers. Industry leaders are well aware of this situation; being a leader cannot be achieved without embracing proven modern and advanced technologies.

Best-in-Class companies in major industries such as aeronautic, automotive, electronics and energy to mention a few, have been adopting, deploying and intensifying the use of engineering simulation as the best, if not unique, way to simultaneously address these combined market pressures demanding Product Integrity, Innovation, Engineering Cost management and Sustainability. Many smart and successful companies, including in the food and beverage sector, are already responding by deploying simulation to take advantage of not only lower engineering costs but the opportunity to quickly test a large number of virtual solutions at low cost.

Just like in any other industry, the race is on between leading food and beverage companies to gain both local and worldwide leadership and market share by bringing more innovation and product integrity to their own products and solutions. Best-in-Class food and beverage organizations follow the lead of successful companies in adopting engineering simulation. The rapid local growth of the digital modeling business in the food business is witness to this natural evolution.

ANSYS Footprint

ANSYS has emerged as a market leader and a visionary by being the first, and so far only, company to bring together the three major physics: fluid or CFD (FLUENT and CFX), structural (ANSYS Mechanical) and electromagnetic (Ansoft) in a single environment.

The simulation that once was understood only by pioneering companies has now been widely adopted as the most effective, efficient and accurate way to predict, challenge and optimize new products in the virtual world, de facto reducing time and cost to market without compromising product integrity and sustainability for innovative products.

But bringing together advanced physics into one environment is not enough, based on feedback from market leaders and engineering simulation users. Making advanced multiphysics technology easily accessible so that engineers, designers and manufacturers can systematically take full advantage of it is the new challenge. ANSYS is currently and continually addressing this. For the food and beverage industry, the plan begins with customization of existing technology to industry specificities and attention to market-driven requirements. Thus, ANSYS is promoting a close relationship with the food and beverage industry and recognizing the importance of innovation in this future high tech industry.

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