Overcoming Business Interruptions and Advancing Product Development with Computer-Aided Engineering

PAMI

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1. Introduction

During the early months of 2020, the world has been affected by the virus pandemic, SARS-CoV-2, which causes the disease known as COVID-19. During this pandemic, acts of self-isolation and social (physical) distancing have been deemed paramount by governments across the globe. Required social-isolation measures and the need to maintain at least 2 m (6 ft) from others have presented unique challenges for many businesses, including those who have an obligation to complete planned, physical testing to meet client or internal project needs. Additionally, fabricating prototype specimens during a time of reduced supplier capacity and physical distancing conditions has become ever more challenging.

This document seeks to offer information on the value of using computer-aided engineering (CAE) as a way to continue product development even when circumstances prohibit traditional physical testing. Additionally, CAE provides an effective method of iterating through many design options to improve product or process performance.

2. What is CAE?

Computer-aided engineering involves the use of specialized software that allows for the simulation, validation, or optimization of products and processes. The most common types of CAE include Finite Element Analysis (FEA) and/or Rigid Body Dynamics (RBD), most commonly used for structural analysis; the Discrete Element Method (DEM), used primarily for bulk material flow, such as grain or soil interactions; and Computational Fluid Dynamics (CFD), used for the simulation of fluids.

Computer-aided engineering, often referred to as simulation or numerical modeling, captures the relevant physics of product or system performance without having to conduct physical tests. This is particularly useful in the challenging times we are currently facing. Through the use of CAE, businesses can analyze the performance of a product or system through the use of specialized software that “digitally prototypes” a structure, bulk material, or fluid. By using the most appropriate of the three common types of CAE tools (**Figure 1**), a business can reduce its physical testing requirements. Numerical modeling can be used to simulate various scenarios well before a final design has been completed, allowing for many iterations and options to be assessed early in the design process. The knowledge gained from modeling specific scenarios enables a business to focus on only the most robust and/or practical outcomes for their physical testing program.

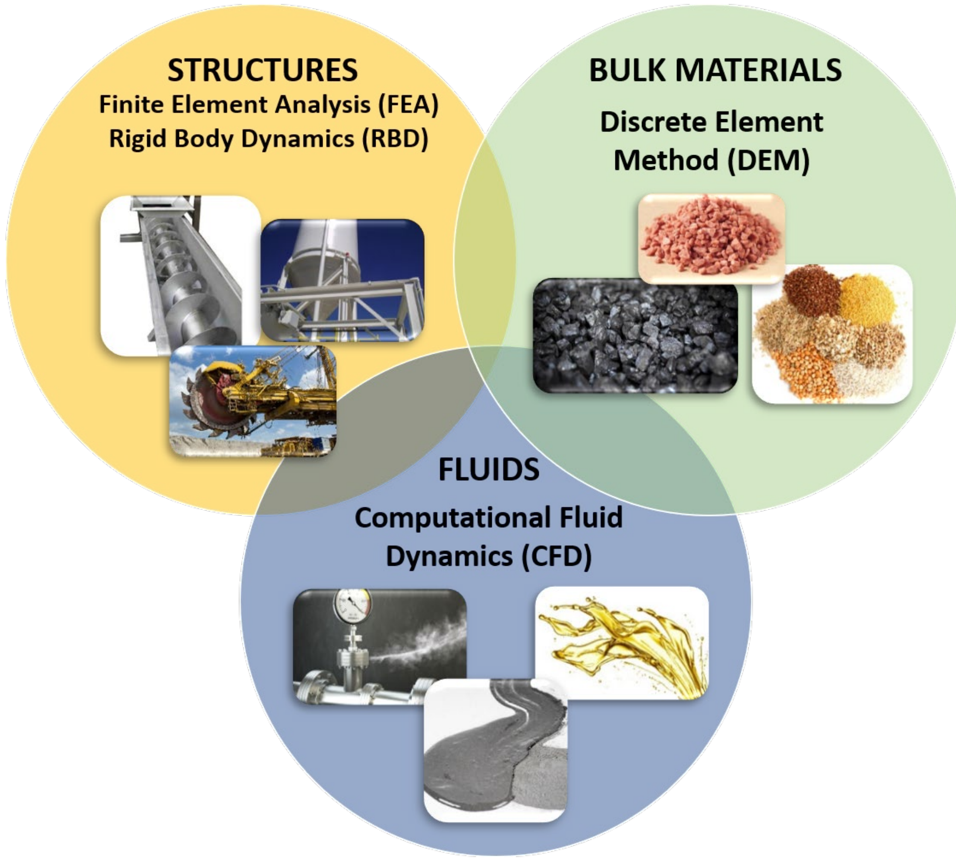

Figure 1. Illustrating the three most common types of CAE; Finite Element Analysis (FEA) and Rigid Body Dynamics (RBD), Discrete Element Method (DEM), and Computation Fluid Dynamics (CFD).

There are several benefits of using CAE, such as enhanced cost efficiency when developing a new product, a reduction in time to market, and a reduction in development costs as a result of reducing technical risk early in the project. Even more relevant at this moment is that CAE allows for the ability to analyze product/system performance at a time when physical testing capabilities are limited or cannot occur.

3. Common CAE Tools

The following subsections detail the three commonly used types of numerical modeling approaches.

3.1 Finite Element Analysis

Finite Element Analysis (FEA) is most commonly used to predict the outcome of structures under specific parameters. Most notably, it is used to investigate complex structures and connections between components and a variety of load cases, both static and dynamic. **Figure 2a** shows an example where component stress was explored in relation to necessary design standards to reduce the risk and delay of unsatisfactory test results. **Figure 2b** shows that components within a model can be easily manipulated to improve the understanding of assembly interactions and contacts. **Figure 2c** shows how cutaway views can quickly be generated to understand product details, such as through-thickness responses in complex loading scenarios.

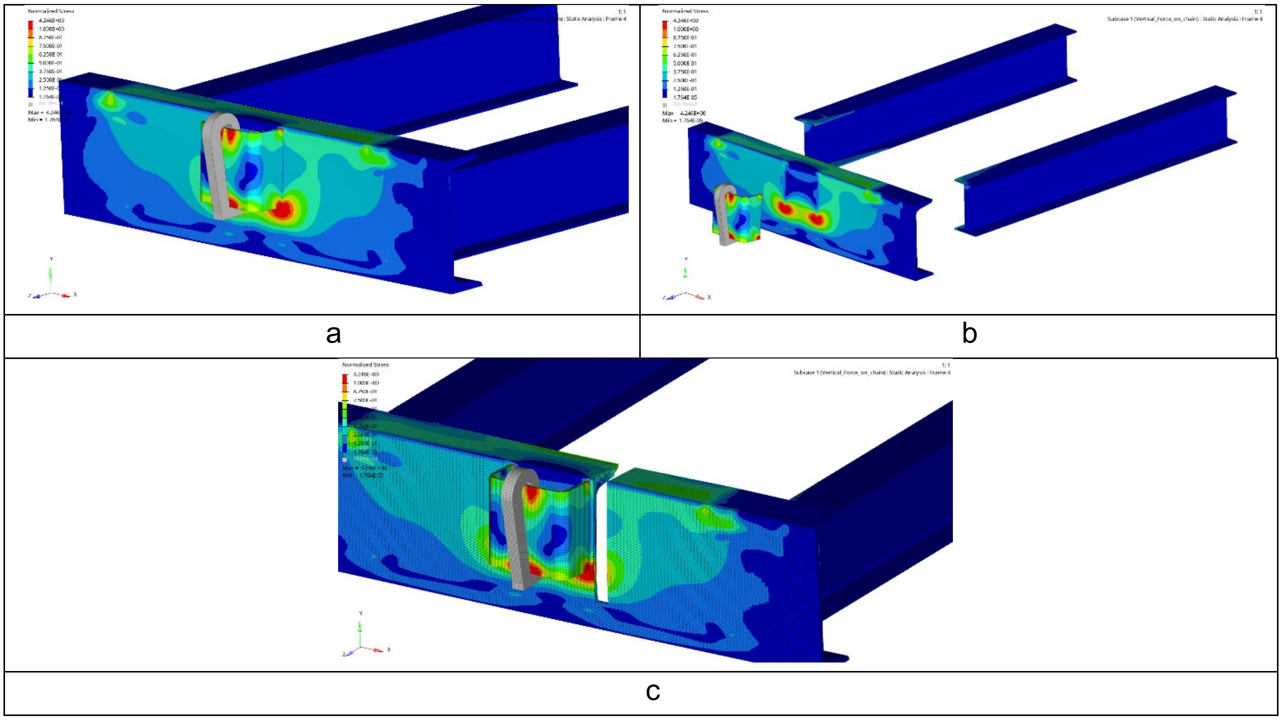

Figure 2. Stress results (a); exploded stress results (b); cutaway stress results (c).

3.2 Discrete Element Method

The Discrete Element Method (DEM) is primarily used to predict the outcomes for bulk material flow, such as grain or soil interactions. DEM can be used to study the fundamental packing behaviours of agricultural commodities under various conditions (**Figure 3a**). DEM simulations can also be used to determine the dynamic arrangement of particles in silos as a function of the filling method and silo geometry (**Figure 3b**). The DEM is ideally suited to study particle breakage, equipment wear, and flow rate in product conveyance applications.

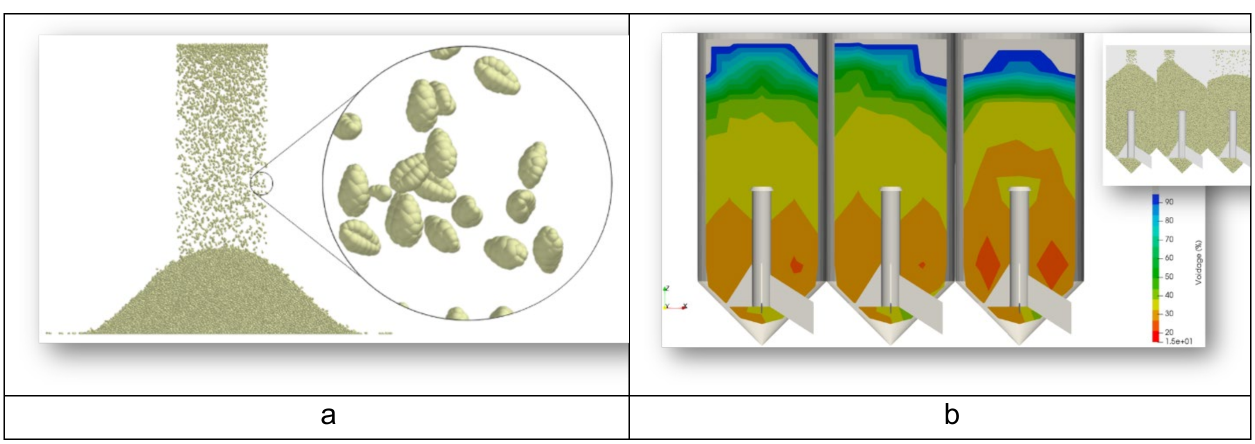

Figure 3. Illustrating packing behaviour simulations (a) and the dynamic arrangement of particles (b).

Machine-soil interactions are commonly simulated using the DEM. For example, as individual particle interactions are represented, tire track development and the distribution of forces acting between a tire and deformable soil can be predicted (**Figure 4** and **Figure 5**). These types of insights not only reduce the burden of a physical testing program, but also permit evaluation criterion that may otherwise be difficult to measure.

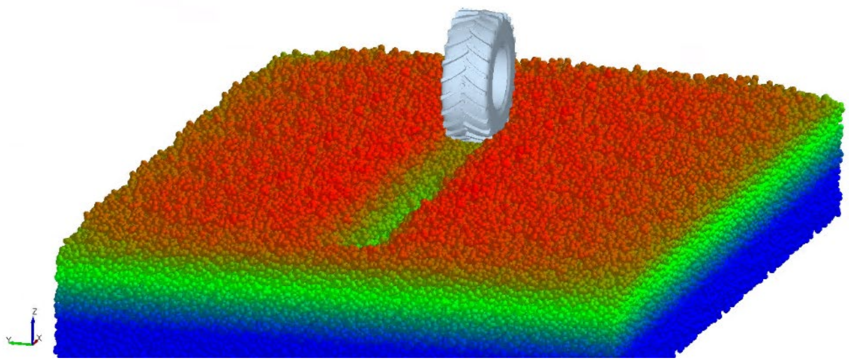

Figure 4. Individual particle interaction shown in tire track development.

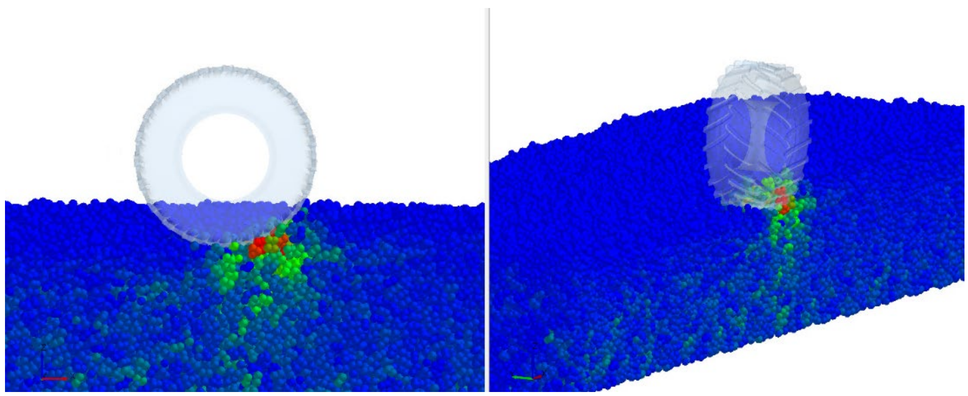

Figure 5. A model showing the distribution of forces between a tire and deformable soil.

3.3 Computational Fluid Dynamics

Computational Fluid Dynamics (CFD) uses numerical simulations to predict how a fluid will flow under a specific set of conditions. For example, WESTEST has used CFD to provide insights into the aerodynamic properties of large, high-clearance sprayers and help identify the machine properties or operational parameters that can reduce spray drift (**Figure 6**).

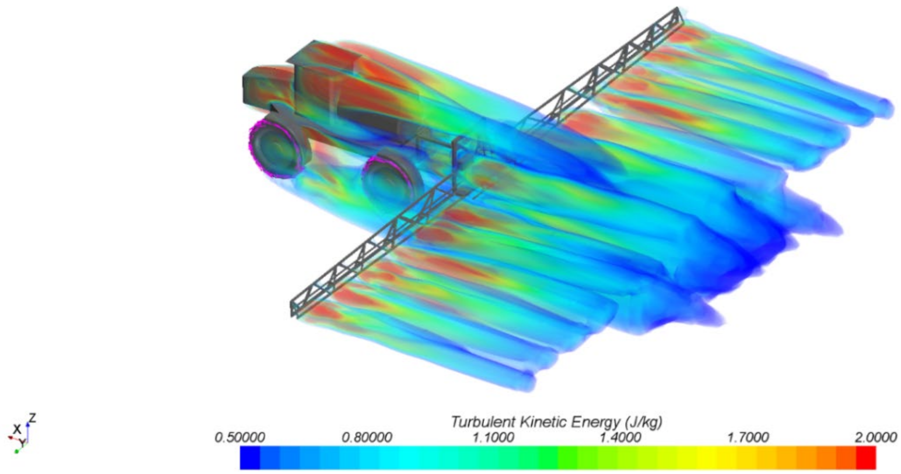

Figure 6. Simulation of fluid properties on a high-clearance sprayer.

Through the coupling of CFD and DEM tools, the behaviour of particles entrained in airstreams can be modeled and studied in great depth (**Figure 7**). This type of simulation technology has applications in many industry sectors, including the pneumatic conveying system of air seeders and dust generation in industrial processes.

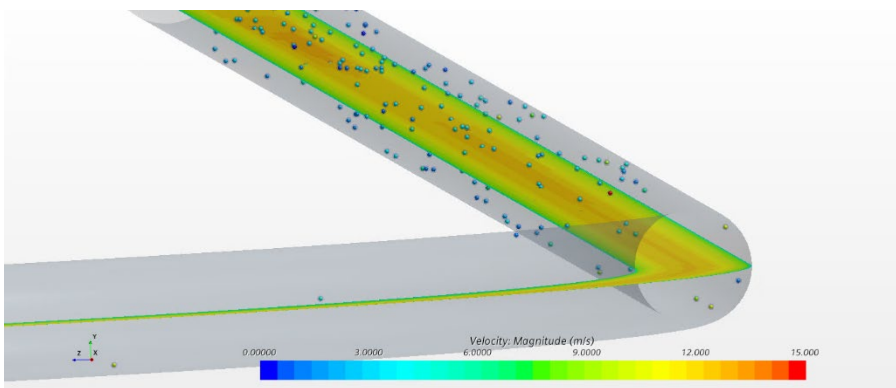

Figure 7. Particles entrained in an airstream simulated using coupled CFD and DEM tools.

4. Summary

Social/physical distancing along with self-isolation measures are presenting unique challenges to businesses that rely on physical testing protocols to fulfill business needs. By leveraging digital analysis tools, a company can digitally test multiple model scenarios and identify those that would most practically convert into a physical test. In general, front-loading the engineering process and using CAE methods allows for enhanced cost efficiency during product development, reduced time to market, and reduced development costs. More specifically, numerical modeling can be used to help businesses continue operating and meeting deliverables through interruptions, such as the pandemic we are currently experiencing.

In short, CAE is a powerful tool that can be used in partnership with physical testing to generate relevant, in-depth product knowledge, allowing for innovation and smarter business.

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