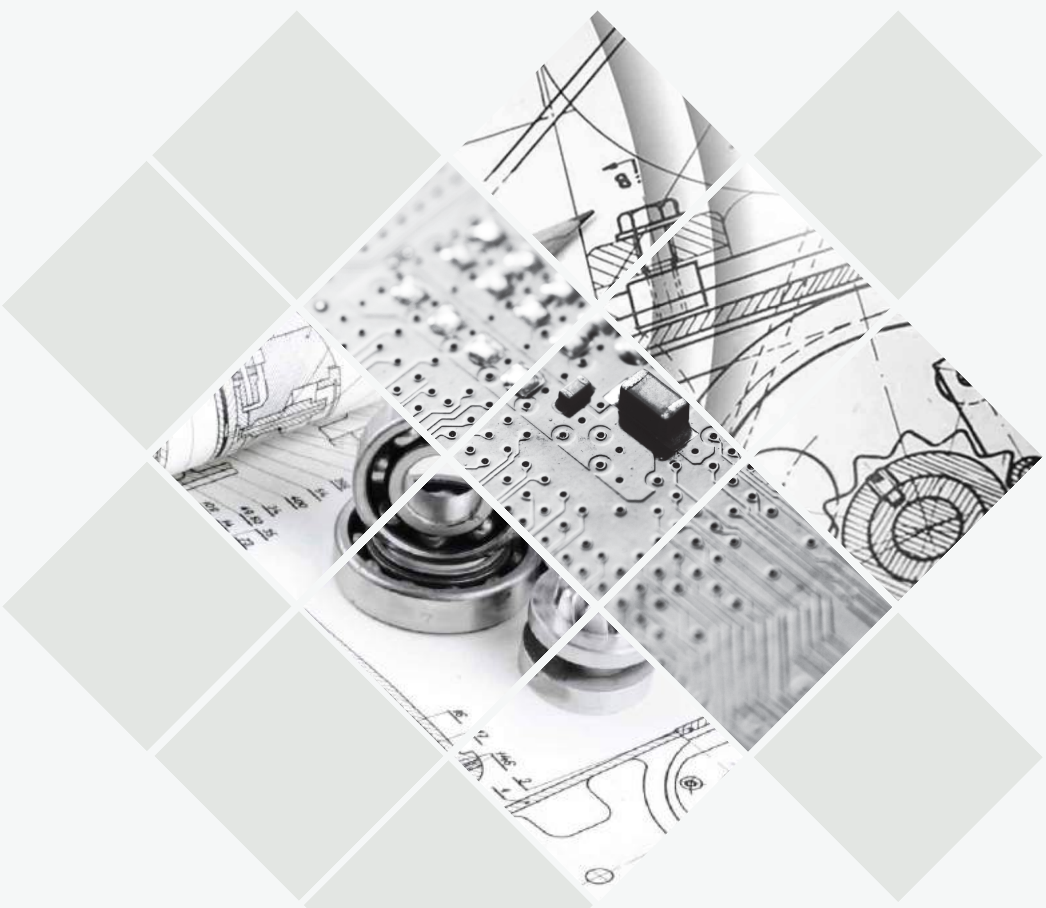
next-generation numerical simulation using isight



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Abstract

At a time when product optimization is the need of the hour, designers across disciplines are looking for utilities which can facilitate faster and easier evaluation of their product under different conditions. Isight is one such tool which provides immense flexibility to integrate several functions. It provides a platform to integrate various tasks of a design evaluation in sequential, parallel and logical manner.

This white paper presents a case study where utilities of Isight have been used for attaining a very high level of simulation automation and optimization. The case study illustrated here is about the design of an in-feed Transformation for Robotic Unscrambler. The challenge of this project was to design an in-feed system that can transport a variety of bottles (ranging from 250ml to 2500ml volume and of different shapes) through various conveyor systems, meeting all the “technical success criteria”.

This case study truly symbolizes next generation in numerical simulation due to its capability and level of automation achieved. Highlights of the capabilities built through Isight include the creation and evaluation of different design variants using a spreadsheet. This excel sheet has around 50 parameters that are used to uniquely define particular design iteration. Towing the similar line in terms of automation, this case study illustrates how hundreds of tasks have been performed using just two manual operations.

Introduction

QuEST is a pure-play engineering service provider which means, engineering analysis is a key aspect of its services. Figure 1 shows the organization's global footprint and team size in the engineering analysis (EA) services space. Its esteemed customer list comprises almost all the major original equipment manufacturers (OEMs) around the world, including, but not limited to, GE, Rolls-Royce, P&G, Airbus, Toshiba, Ford, Siemens etc.

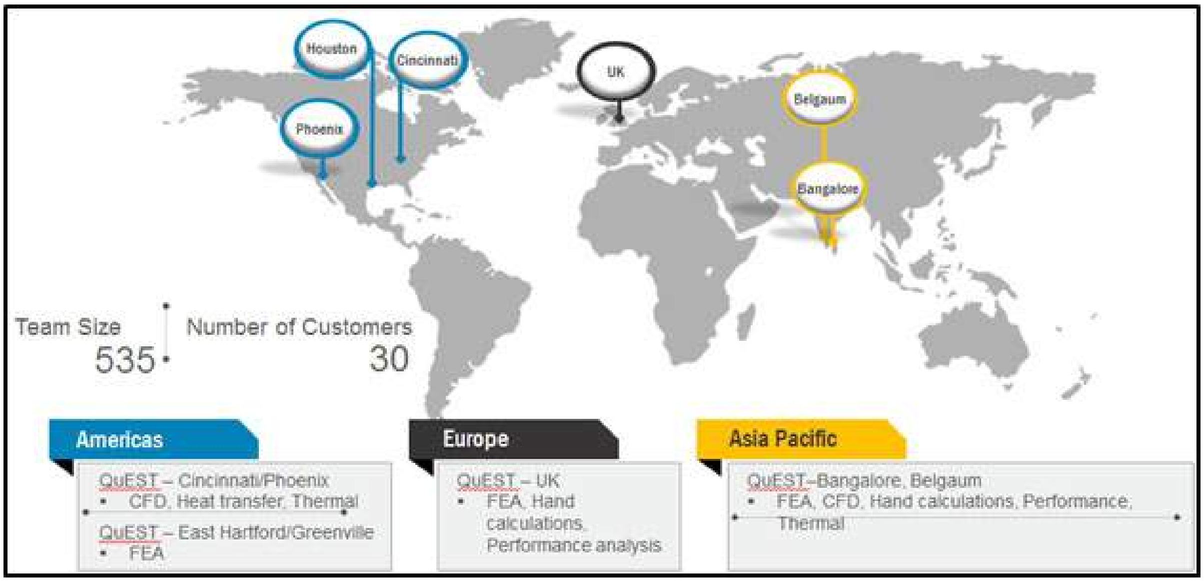

Figure 1: EA-Delivery Centers' Global Footprint (Ref. 1)

For most of these marquee clients, QuEST delivers end-to-end solutions for their design iterations. This document presents a case study in which one of our customers was looking for a new design of the unscrambler to mitigate the conveyor changeover cost in bottling plants. A change in a bottle's specifications (shape or size) in a plant necessitates a stoppage in production to allow the unscrambler unit to refit the appropriate conveyor belt. The opportunity cost because of production stoppage and unit changeover was significant. This necessitated a change in the design of the unscrambler unit, which is capable of accommodating bottles of different shapes and sizes. This was termed as “blind to shape” design, and the engineering solution to support the design, was developed by QuEST in collaboration with the customer. The engagement began with a QuEST engineer posted at the customer plant taking hand measurements of different parts of the unscrambler unit. A sketch was created of the unit on a piece of paper. This sketch laid the foundation of the numerical model which QuEST went on to build. All the design variables and other model set-up parameters were decided in consultation with the customer.

There are several commercial tools available to perform such activities but Isight was chosen based on the customer's preference. The following sections describe some of these tools which can be used for similar purposes.

Commercial Tools:

This section provides an overview of four commercial tools that support an integrated platform for designing the appropriate solution.

ANSYS Workbench:

The ANSYS Workbench platform is the framework unifying our industry-leading suite of advanced engineering simulation technology. An innovative project schematic makes it possible to build even complex multiphysics analyses with drag-and-drop simplicity. With bidirectional parametric CAD connectivity, powerful highly automated meshing, an automated project-level update mechanism, pervasive parameter management and integrated optimization tools, the ANSYS Workbench platform delivers unprecedented productivity, enabling process capture and simulation driven product development [2].

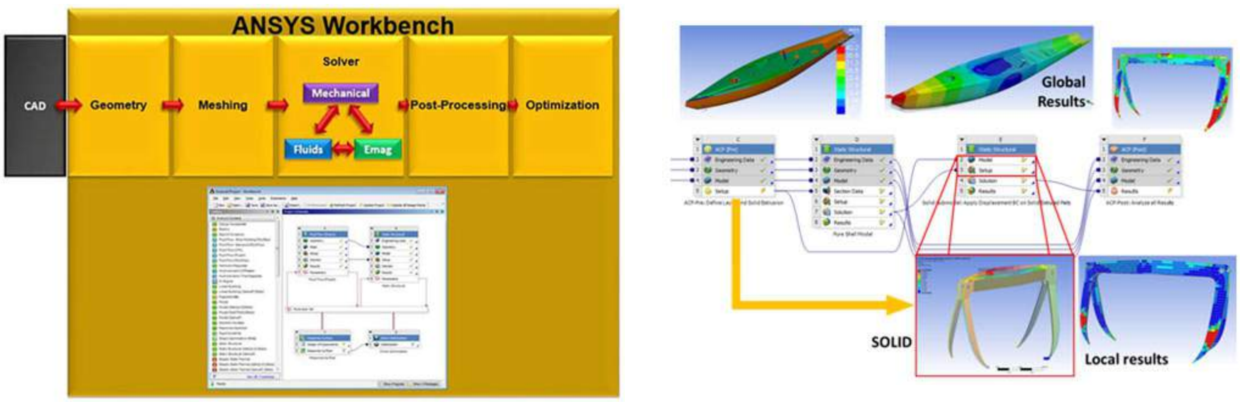

Figure 2: ANSYS Workbench GUI (Ref. 2)

Siemens NX:

The Siemens NX software is an integrated product design, engineering and manufacturing solution that helps industries deliver better products faster and more efficiently. It enables smarter decisions in an integrated product development environment.

NX provides following key capabilities for fast, efficient and flexible product development:

- Advanced solutions for conceptual design, 3D modeling, and documentation
- Multi-discipline simulation for structural, motion, thermal, flow, and multi-physics applications
- Complete part manufacturing solutions for tooling, machining, and quality inspection [3]

Figure 3: PLM with NX

Hyper Study:

HyperStudy enables users to explore, understand, and improve their designs using methods such as design-of-experiments, response surface modeling, and optimization. Results from these studies can be easily analyzed and interpreted using HyperStudy's advanced post-processing and data mining capabilities. HyperStudy's intuitive user interface and its seamless integration with HyperWorks for direct model parameterization and CAE result readers, simplify the study setup [4]. HyperStudy can do experiment design (DOE), optimization, robustness evaluation for design variables, error factors, and responses. These are collectively referred to as studies. There is an interface with notable external solvers (LS-DYNA, ANSYS, NASTRAN, etc.), and it is possible to study various phenomena such as nonlinear structure analysis and fluid analysis.

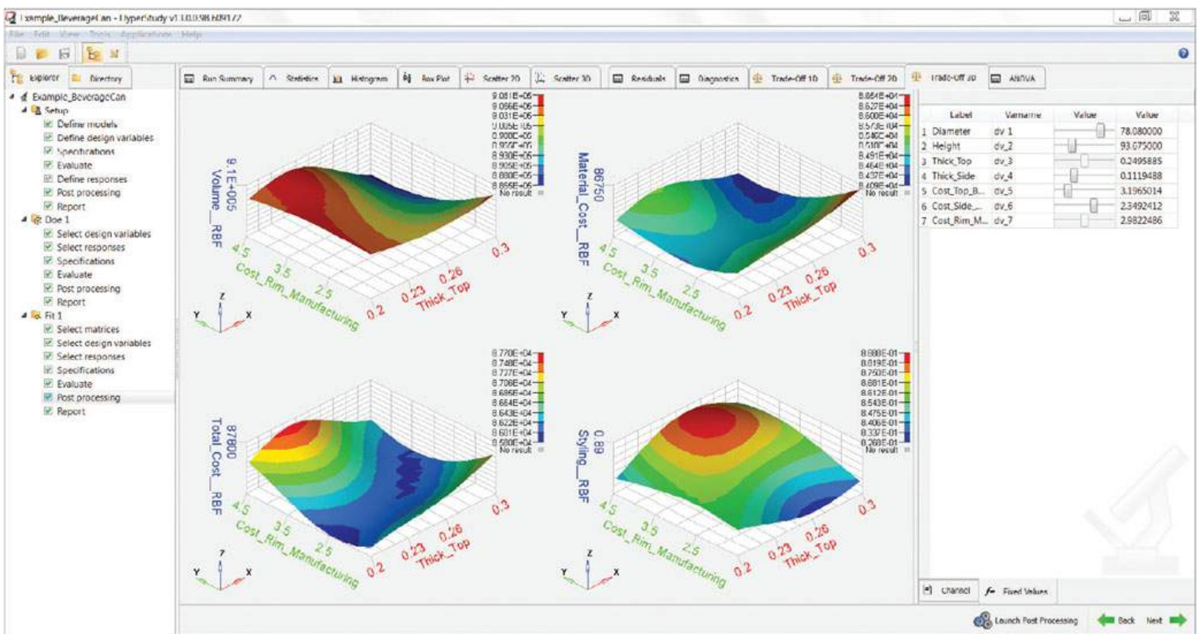

Figure 4: HyperStudy GUI (Ref. 4)

Isight:

Isight and the SIMULIA Execution Engine (formerly Fiper) are used to combine multiple cross-disciplinary models and applications together in a simulation process flow that automate their execution across distributed compute resources, explore the resulting design space, and identify the optimal design parameters subject to required constraints [5].

Isight provides a standard library of components i.e. including Excel™, Word™, CATIA V5™, Dymola™, MATLAB®, COM, Text I/O applications, Java and Python Scripting, and databases for integrating and running a model or simulation. These components form the building blocks of simulation process flows [6].

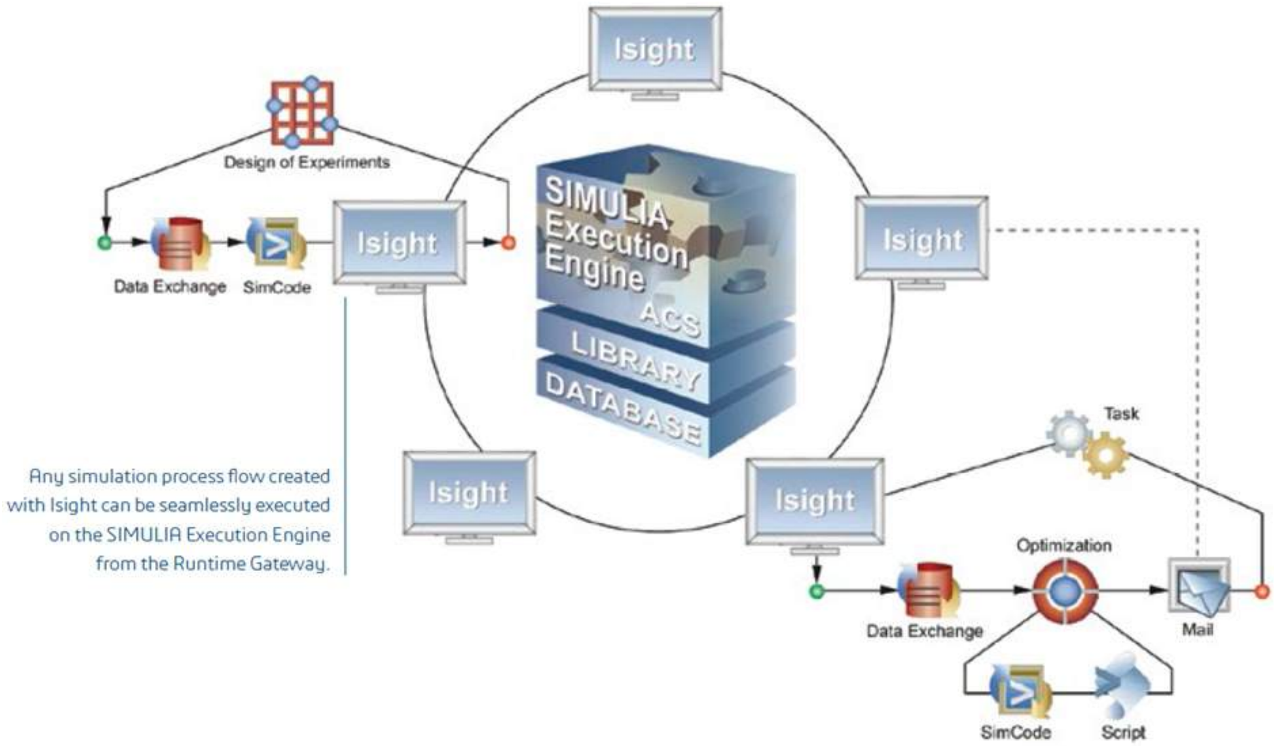

Figure 5: Isight framework (Ref. 6)

Isight Model:

The QuEST team built a gigantic Isight model to evaluate an "Infeed transformation for Robotic Unscrambler" supporting one of our prestigious FMCG customers. The purpose was to design a conveyor system that is "blind to shape" and could successfully transport bottles from the dumper to different conveyors till they are picked up by the robotic arms. Successful transportation of the bottles was evaluated by technical success criteria defined in terms of conveyor pattern, bottle position, front label location, and stability. Bottle stability itself had different criteria such as stability during transport and sudden start or stop.

Within the scope mentioned above, the customer intended to design a standard infeed transformation which could be used in all new packing line executions. This was the purpose for which Isight model was built. The basic functionalities of this Isight model were:

- To include all variable parameters to be used for design, analysis, and result extraction
- To create a numerical model for bulk bottle-feeding, transport, and separation, based on the inputs generated through the variable parameters
- To perform numerical simulation and result extraction for various design iterations

Figure 6, shows a typical assembly sketch along with nomenclature of different parts that were considered in the numerical model.

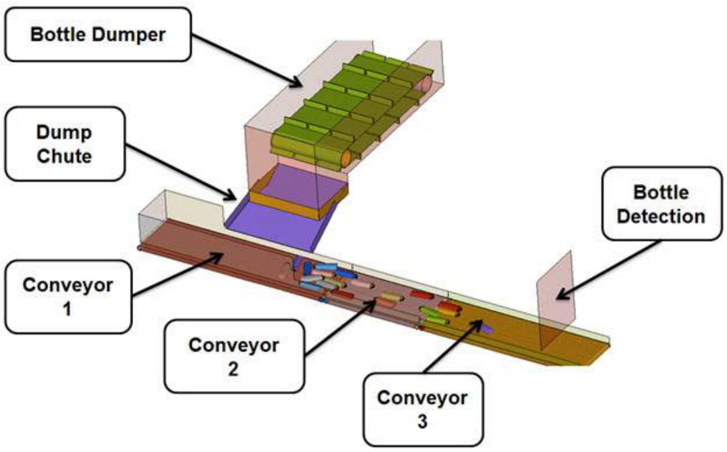

Figure 6: A typical assembly sketch (Ref. 1)

Broadly, Isight model functionality could be described using following modules. 1) DoE generation called DOX generator, 2) Model configuration, and 3) Run and post-processing.

Figure 7 shows a high-level architecture of this model. The modules that constitute this model are:

- DOX generator: It is a Microsoft Excel-based interface that enables the user to assign values to the design, analysis, and set-up variables. In other words, it is a gateway for all design iterations wherein the user manually devises his iterations through the Excel interface. It has more than 50 predefined variables that facilitate design iteration and maintain uniqueness of each variable across all the modules of Isight. Based on these inputs, the DOX generator creates a text input file which is linked to the Isight model, which subsequently processes the file.

- Model configuration: The afore-mentioned Excel interface provides various options for different model configurations, including:

  a. Full transformation model, which includes a hopper (bulk package feeding) with randomized options for bottle positioning and dropping

  b. Partial transformation model, which uses a bottle pattern created manually instead of a hopper on a separation conveyor.

  The purpose of the partial transformation model was to study bottle separation and settling while the full transformation model could also throw light on bottle dumping and layering, although at the expense of analysis time. Over and above the different model configurations, the architecture also has a provision for performing post-processing using only the existing result files.

- Run and post-processing: Based on the input provided by the DOX generator, Isight creates geometry, FE model (mesh, loads, boundary conditions, contacts generation etc.) and an input deck. Subsequently, it submits the job, performs post-processing, and creates result output files.

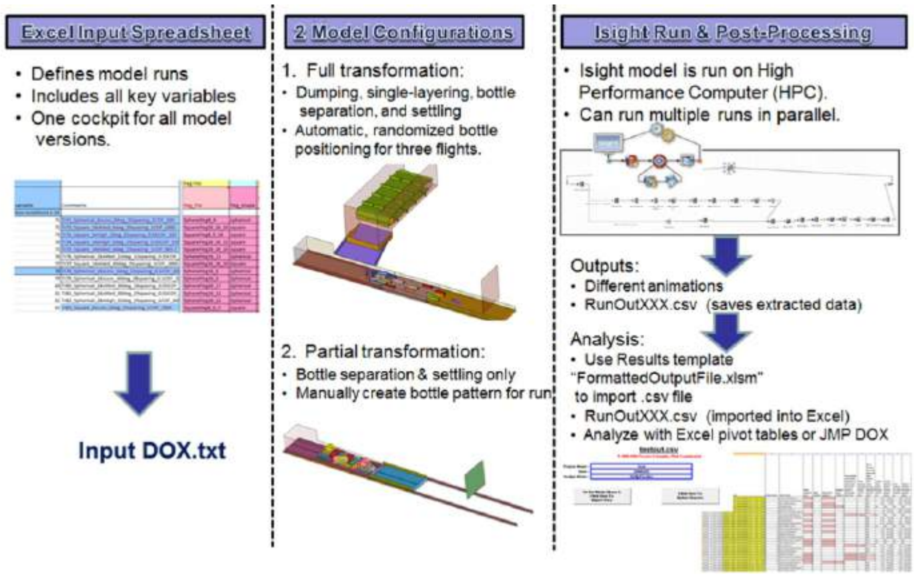

Figure 7: High-Level Model Architecture (Ref. 1)

All the inbuilt functionalities of the Isight model described above require a carefully crafted framework and high levels of automation. Some of the key automated features of the model include:

i) CAD and FE mesh creation of the patterned conveyor with inputs from an Excel spreadsheet on shape (spherical, square, rectangular, semi-spherical etc.), size (length, width, height, radius etc.), and pattern (equidistant, biased, inclined at different angles etc.)

ii) Random positioning of the bottles in prescribed open space

iii) Assembly processing with the appropriate numbers and types of bottles, conveyors, dumpers, flights, rollers etc.

iv) Input deck creation for submitting an LS-Dyna run, which includes the creation of contacts among different parts, run options etc.

v) Result extraction which includes, displacement, velocity, angle, stability, location, position, images etc.

Figure 8 shows the Isight model built by our team.

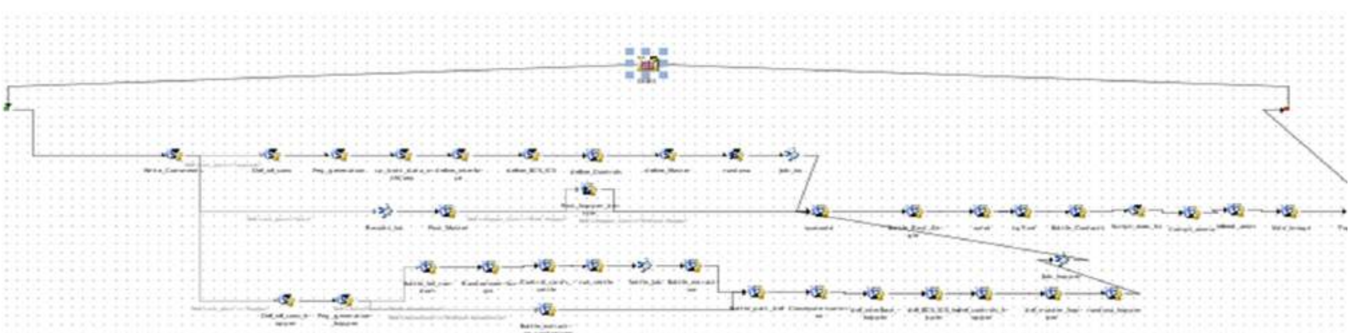

Figure 8: Isight model (Ref. 1)

The entire process for design study involves only the following two manual steps:

i) Filling-up the excel sheet, saving it as "Comma separated file" and transferring it to required server directory.
ii) Copying all the results files (.dat, .csv, images etc.) back to the desktop from the server

This Isight model provided a platform for the customer to explore various scenarios, which would otherwise have been time-consuming and cost-intensive. More than 200 design iterations were conducted to reach a conclusion.

Benefit

As mentioned in the abstract, the Isight capability demonstrates our readiness for providing an end-to-end solution. It is a business imperative to move up the value chain to remain relevant and profitable against time. It is even reflected in our vision and mission statements. If we want to be a recognized engineering company and a comprehensive solution provider to our customer, capabilities like the one presented in this paper are mandatory. It showcases our capability to integrate all design activities in a framework and automate the processes to the maximum possible level. In this case, the Isight model not only reduced effort by 70 to 80% but also made the process robust by eliminating human errors. This framework, though devised for a packaging line of an FMCG product, can be leveraged across all product lines, be it aero-engines, aero-structures, gas turbines, steam turbines, oil and water etc. All the OEMs work on New Product Introduction (NPI), Performance Improvement Plan (PIP) or redesign activities. This capability can act as a significant saleable point for all these activities.

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About the author

Satish is a technical expert in finite element analysis with an experience of around 15 years in the domain. He has a diverse domain experience, which includes FMCG, Power Generation, Automotive, and Industrial, apart from aerospace engineering, in which he has an experience exceeding 9 years.

Satish has worked extensively with structural linear/non-linear analyses with contacts, natural frequency analysis, and impact dynamic analyses like Fan Blade Out and Tip rub. He also has exposure to harmonic, transient thermal and structural-acoustic coupled field analysis. He is proficient in a wide range of CAE and CAD tools such as ANSYS, Abaqus, LS-Dyna, Isight, and UGNX. He has also mentored engineers working on other tools like Hypermesh, and NX-Nastran.

He is associated with QuEST for more than 6 years and has supported many first-off projects. He holds a Master's degree in Mechanical engineering from IIT Kharagpur and has completed Leadership Development Program from GlobalNxt University.

He has been conferred “Trade Secret Award” for his work on "Coupled Structural-Acoustic Analysis" from his previous organization.

He has also authored the following papers:

1) Future of Engineering Analysis, FEA (Finite Element Analysis) in particular, for a consulting firm like QuEST

2) Use of LSDYNA tool for predicting Fan Blade Out (FBO) response

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