Optimization and Flowchart Control in the Industry Process using Abaqus, CATIA, Moldflow with Isight Integration

Mariana Batista [a] , Ruben A.G. Guardia [b c]

a Smarttech LTDA, Av Brigadeiro Faria Lima, 2894 São Paulo Brasil, Email: mariana.batista@smarttech.com.br
b Smarttech Sudamerica S.R.L Dardo Rocha 3168 Piso 2 Oficina B, Buenos Aires, Argentina
c Engineering School, Universidad Tecnologica Nacional, Email: ruben.guardia@smarttech.com.br

Abstract

In an increasingly competitive world the optimization processes play an important role in the industry. The continuous development of technology to help these processes make it possible to achieve integration for one of the most important objectives—to reduce costs. In most cases, the optimization is performed with outdated methods and even trial and error which do not always achieve the objectives and are processes that take a long time to be done.
The key aspect of the optimization process is the ability to integrate different analysis models such as: injection, structural, thermal, modal, thus gathering as much information as possible to achieve our goal. It will be shown how to perform this integration with Isight as a manager of several different solvers and how all work together with our main goal: optimization. These processes will include different simulation software such as CATIA, Abaqus, Moldflow, Isight, all together in one workplace.

Keywords: optimization, Isight, CATIA , Abaqus , industry process, flowchart control, Excel, Moldflow

---

1. Introduction

In the industry field there are processes that can take advantages from optimization. Currently there are several methods to achieve a result and most of them end up in an iterative process involving different working fields that require different criteria. All these areas are separated and each time one requires some modification, they are all checked again in order to verify that all criteria are met.
Some optimizations have been done in this work using several integrated tools with Isight, such as Excel, CATIA, Moldflow and Abaqus. Initially there is a brief explanation of Isight with some setup screens that bring an idea of the overall process.

After that a case study that was used in the automotive industry is discussed; the goal was to perform an optimization to reduce cost as well as the desired criteria.
Abaqus was used to study the stresses and displacements and Moldflow to know the injection pressures, temperature and processing time, CATIA to change some part of geometry and getting our goal, Excel to be the interface between the user and model.
Finally comment some issues about the orientations of material in the moldflow simulation very important in some analysis.

2. What is Isight ?

In today's computer-aided product development and manufacturing environment, designers and engineers are using a wide range of software tools to design and simulate their products. Often, the parameters and results from one software package are required as inputs to another package, and the manual process of entering the required data can reduce efficiency, slow product development, and introduce errors in modeling and simulation assumptions. Isight is used to combine cross-disciplinary models and applications together in a simulation process flow, automate their execution, explore the resulting design space, and identify the optimal design parameters subject to required constraints. Isight's ability to manipulate and map parametric data between process steps and automate multiple simulations greatly improves efficiency, reduces manual errors, and accelerates the evaluation of
product design alternatives.

3. Introduction.

Isight is a desktop solution that provides a suite of visual and flexible tools for creating simulation process flows—consisting of a variety of applications, including commercial CAD/CAE software, internally developed programs, and Excel spreadsheets—in order to automate the exploration of design alternatives and identification of optimal performance parameters.
Isight enables users to leverage advanced techniques such as Design of Experiments, Optimization, Approximations, and Design for Six Sigma to thoroughly explore the design space.
Advanced, interactive post processing tools allow engineers to explore the design space from multiple points of view as shown in Fig. 1.

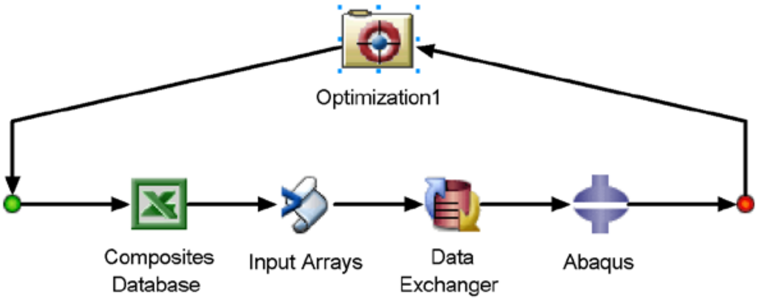


Fig. 1. Example of Isight process.

In addition to advanced simulation techniques, Isight provides tools to integrate with many applications. This variety of tools that are available to allow interconnection between them, makes Isight a powerful application to integrate different platforms quickly and easily.
Isight has many options for CAE / CAD / Math and Multi purposes as shown in Fig 2.

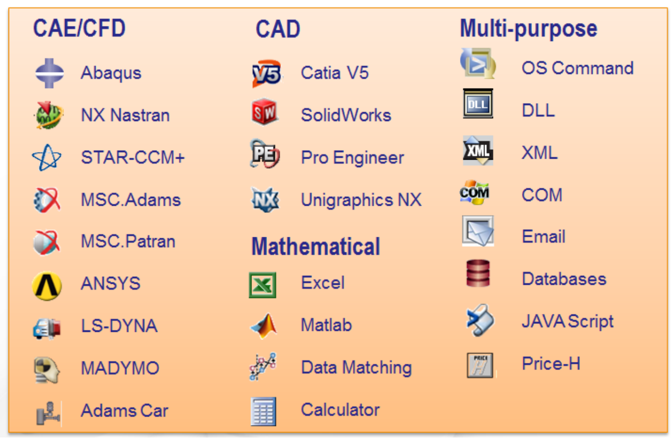


Fig. 2. Some of the most important library components in Isight

Each of them has the necessary options to control externally to the software. For example in the case of the application with Abaqus, we can load the INP file, which is our data file containing the configuration of the model we want to simulate and from we will take the data on which we want to have a variability. This information can be seen in Fig. 3.

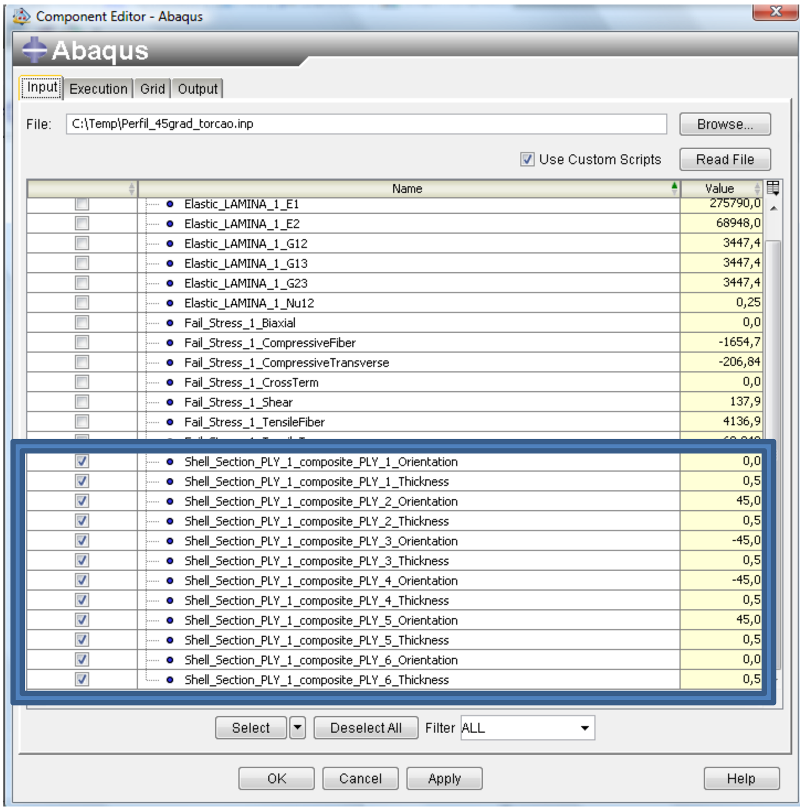


Fig. 3. Windows of load INP file.

For the case shown corresponds to an information analysis of one Part of composite having a shell model with multiple plies, defined orientation, and thickness. These are the variables that can be defined and will be studied in all Isight simulation techniques.

The material data including elastic modulus, poisson's ratio, boundary conditions, loads and everything needed for the model will be included in the inp file information.

We will have to define the implementation process of the simulation in Abaqus, among several options that we want to extract data output file and what is the number of CPUs that Abaqus uses in the simulation and others as shown in Fig. 4.

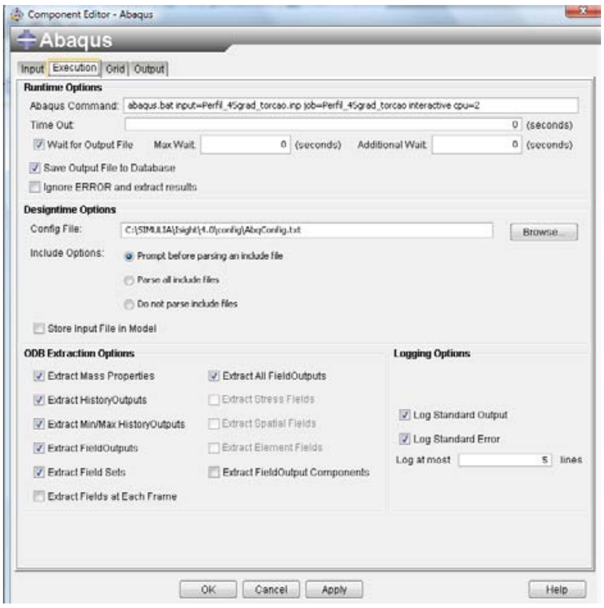


Fig. 4. Execution option

We have to indicate what will be our goal, if we want to optimize a particular variable, in this case the variable we take as a case of verification are tensions of TSAI-WU and TSAI-HIW. These two stress modulus must be lower than 1 case to verify the component. Isight can generate and manage all simulations necessary to achieve the objective.
Loading our ODB file outputs in Isight, we can view the variables of interest and select them as shown in Fig 5.

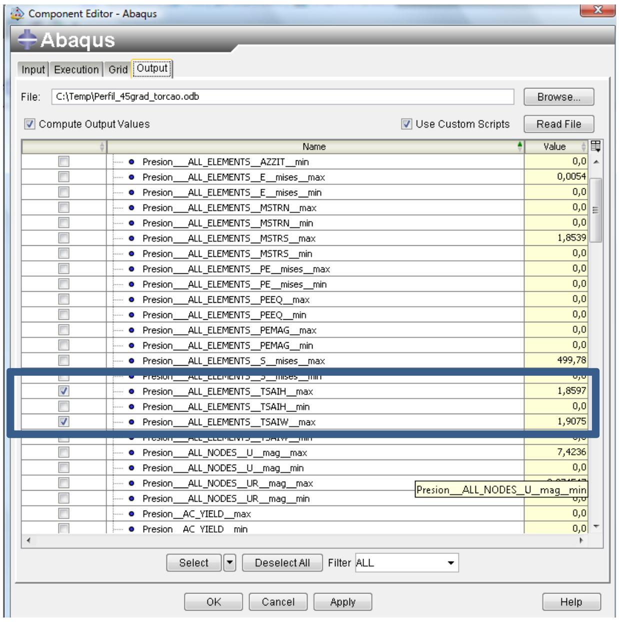


Fig.5. Load of ODB file.

Isight offers an extensive library of parallel process components, such as Design of Experiments & optimization as well as Approximation methods that enable engineers to thoroughly and quickly explore the design space.

3.1. Design of Experiments

The Design of Experiments (DOE) component enables engineers to quickly assess the impact of the various design variables on the objectives and identify significant interactions among the design variables. The structured set of design data produced by DOE runs also can be used in conjunction with approximation models for use with optimization methods. Methods included are central composite, full and fractional factorial, Box-Behnken, Latin Hypercube, optimal Latin Hypercube, orthogonal arrays, and parameter study. In addition, an external data file can be used to define the matrix of experiments.

3.2. Optimization

Isight provides a comprehensive selection of parallelized optimization techniques that can be applied to a variety of problems. These include numerical optimizers such as NLPQL, LSGRG-2, Hooke-Jeeves, Adaptive simulated annealing, Downhill simplex, MOST, Multi-Island Genetic algorithm as well as the Pointer-II automatic optimizer—an easy-to-use parallel hybrid technique that can tune itself. The software also includes several techniques that can handle multi-objective optimization problems like the archive based micro genetic algorithm AMGA, Particle Swarm, NSGA-II and NCGA.

3.3. Data Matching

Data Matching is a process in which simulation models are calibrated by minimizing any of a variety of different error measures using optimization techniques. Target data can be either imported experimental results or simulation results generated by a higher-fidelity code.

3.4. Approximations and the Visual Design Driver

Approximations are powerful real-time tools to interpolate results of computationally intensive realistic simulations. They can be created using the response surface method (RSM), radial, elliptic basis functions or Kriging. A setup wizard guides users in defining an approximation mode that can be used anywhere in the simulation process flow. Approximation models are automatically cross-validated to ensure accurate predictions. The Visual Design Driver allows users to see their approximation models from many different views and "surf" the design space graphically and interactively.

The Visual Design Driver window provides a parameters panel that can display the parameters in either a slider or table interface. The sliders are directly coupled to all plots currently being viewed, and the plots change as the sliders are moved.

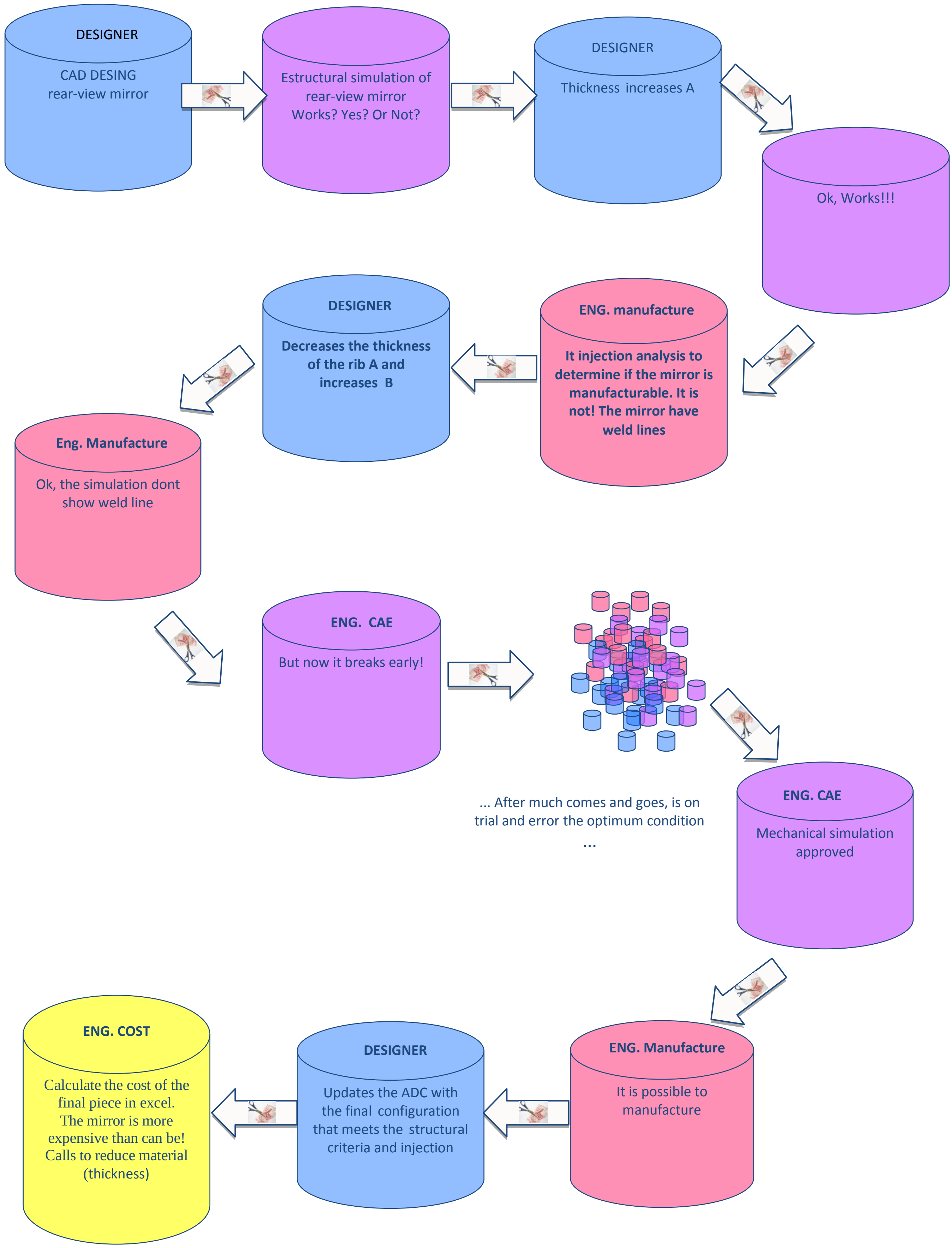
3.5. Quality Methods

Isight provides stochastic methods that account for variation in product designs and the environment in which they operate. The Monte Carlo Simulation (MCS) component offers an accurate method to address uncertainty and randomness in the design process. It allows users to sample the design space, assess the impact of known uncertainties in input variables on the system responses, and to characterize the statistical nature (mean, variance, range, distribution, etc.) of the responses of interest. The variations in input parameters can be specified as exponential, Gumbel, normal, skewed-normal, log normal, triangular, uniform, discrete-uniform, and Weibull distributions. Both random and descriptive sampling methods can be invoked. The MCS component can also be used in conjunction with the approximation methods.

Using the Six Sigma reliability and robustness analysis component, a product or process is simulated repeatedly while varying the stochastic properties of one or more random variables to characterize the statistical nature of the responses of interest. The "sigma level" or probability of satisfying design specifications, is reported along with performance variation statistics. The reliability analysis can be performed with a parallel 1st or 2nd order method, a Monte Carlo or a DOE.

The Taguchi component can be used to improve the quality of a product or process by not only striving to achieve performance targets, but also minimizing performance variation.

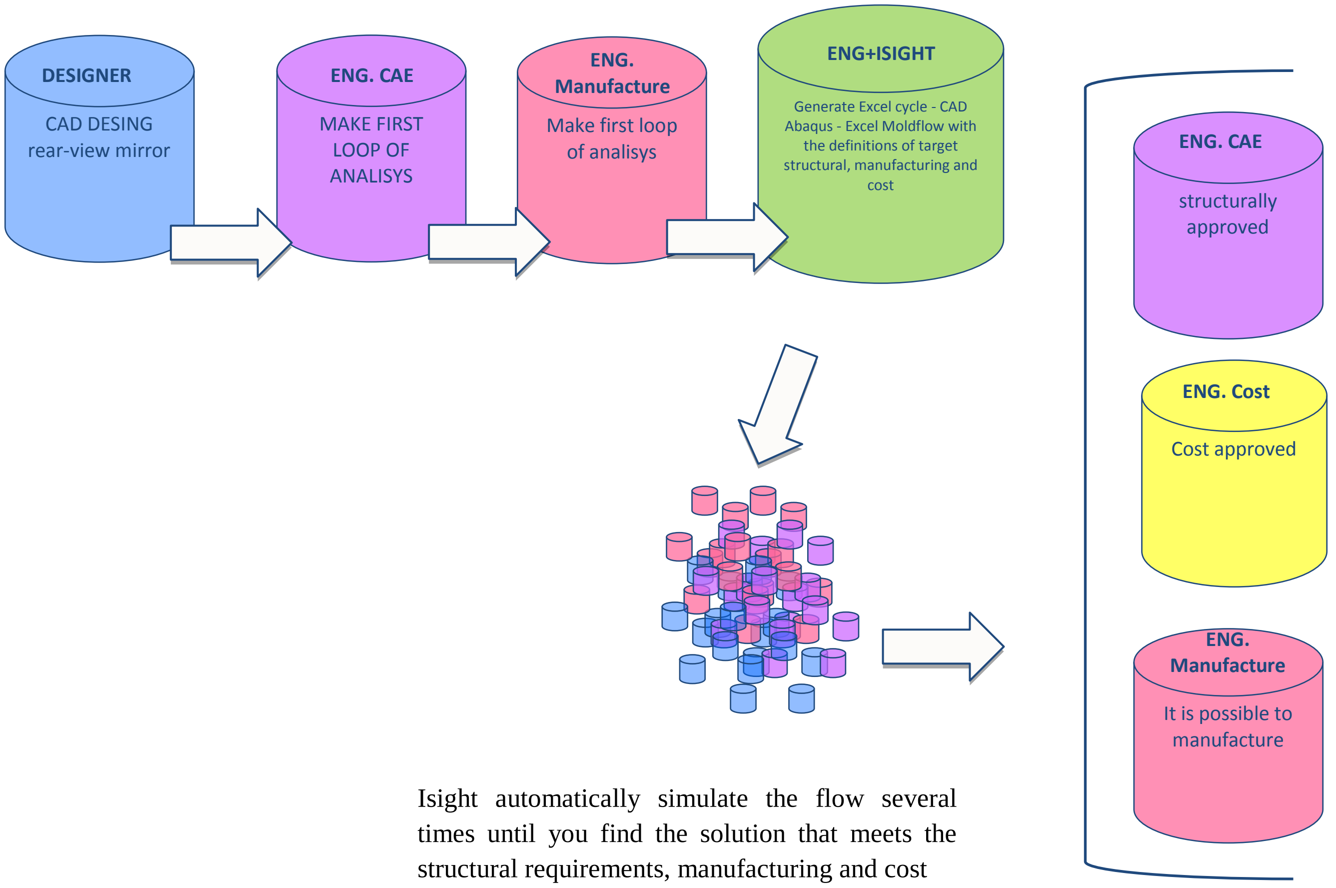
4. Optimization procedure without Isight.



As shown in the above scheme without Isight process include several engineering and several checks that are difficult to optimize. At the end of this process a product cost is likely much higher than desired.

5. Optimization procedure with Isight.

The process using Isight is much more efficient and gets to the end with a much lower cost to meet the necessary requirements.



6. Study Case.

We analyzed a model rear-view mirror of the automobile industry in which must meet structural, manufacturing criteria and cost as shown in Fig 6.

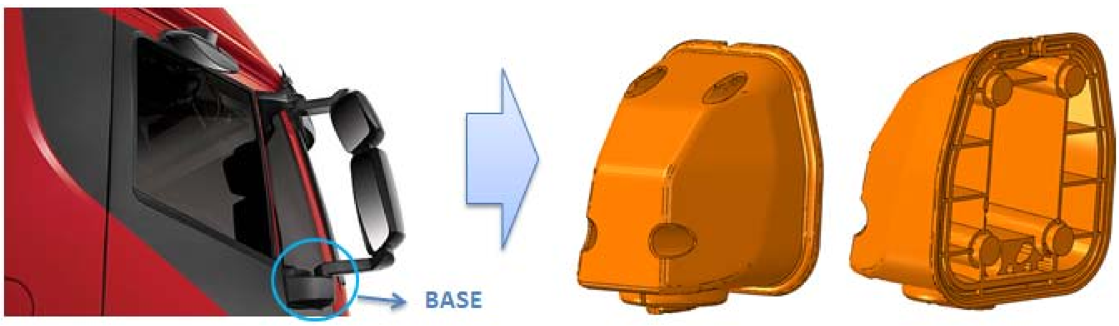


Fig 6. Rear-View Mirror part

For each of these criteria will be evaluated: for the first, limit of the material stresses and natural frequencies; for the second criterion the temperature, pressure and deformation of the workpiece and the third criterion for the saving of material which directly affect the cost. The variable in this case we are adjusting are the thicknesses of the ribs as shown in Fig 7..

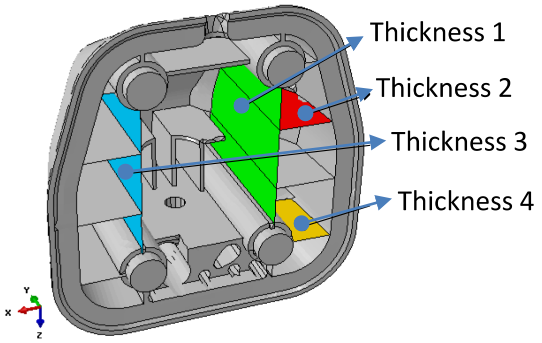


Fig 7. Thickness of rear-view mirror part

7. Description of the information flow

As mentioned in the introduction, how to prepare the Isight models are very simple, only sufficient to assemble the wiring according to the desired process. For the case described shows the flow chart Fig 8. and configured for each case the corresponding parameters.

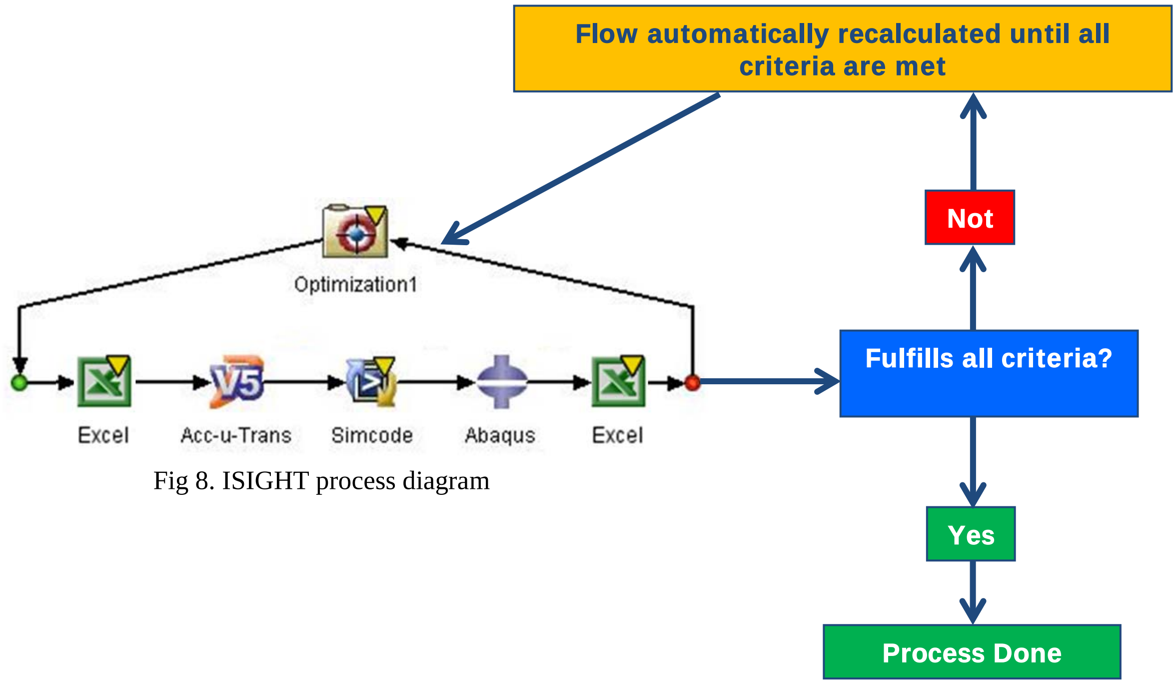


Fig 8. ISIGHT process diagram

Then we will make some general comments on each of the libraries shown in Fig 8. The components in the process are shown in detail in Figure 9.

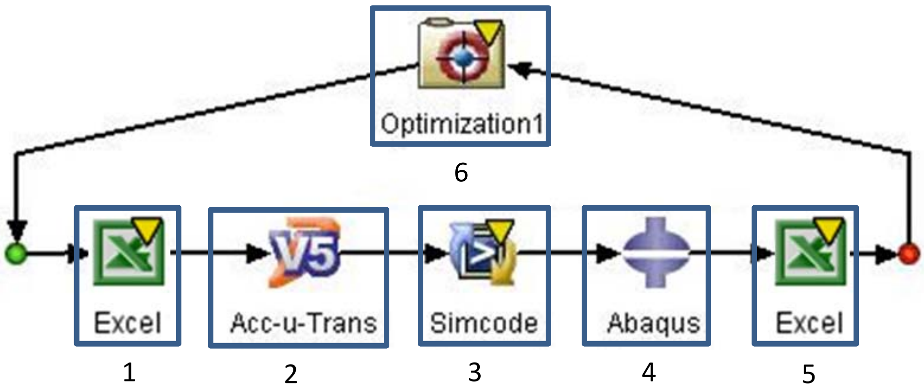


Fig. 9. Isight process diagram.

In Fig 9 we can detail the six different processes, in block 1 is put the input data for this case we used a spreadsheet using Excel as the user interface to be placed in the same all the data necessary to perform simulations, such as material data, maximum cost of the part, number of frequency modes to be analyzed, frequency limit for the first mode, the value of the force is to be applied to the rear-view mirror part and the criteria for maximum stresses and peak displacement. Shown in Fig 10 the Excel sheet input

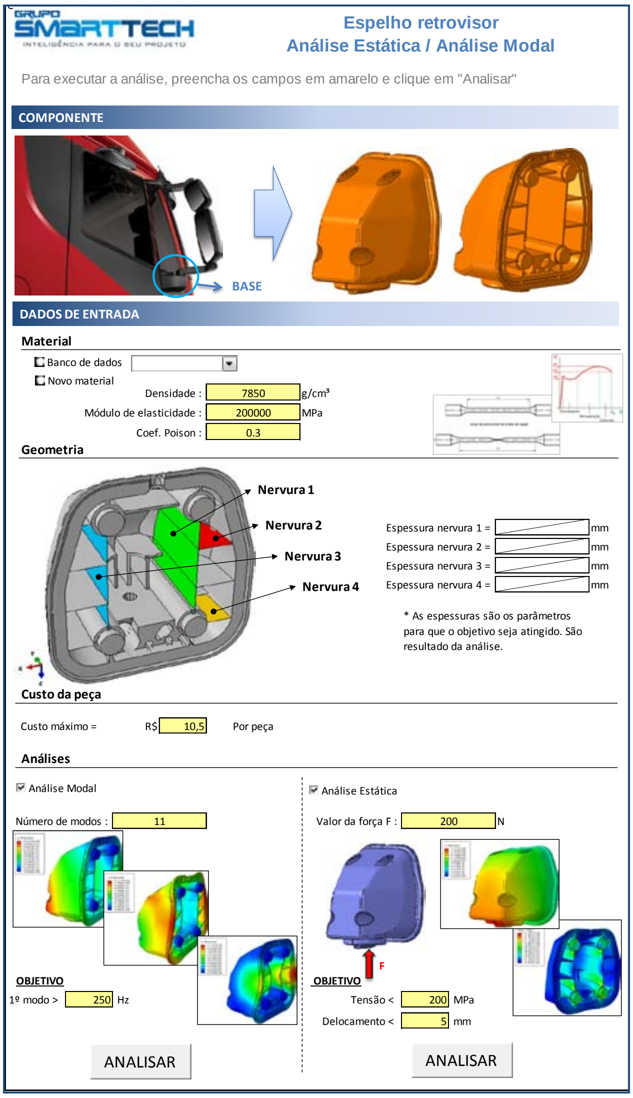


Fig. 10 Data Entry Form Excel

In block 2 of Fig 9 corresponds to the library ACC-U-TRANS is responsible for carrying the interface to CATIA V5 to change automatically depending on the input geometry we are considering, after this modification geometry from entering into the block 3 which manages call SIMCODE simulation with Moldflow calculating the parameters of pressure, temperature and deformation of the injection process. In block 4 called Abaqus modify the INP file with all data that have been put in block 1 and calculate the maximum stresses, natural frequencies and deformations.

After these simulations, the data are placed in an Excel spreadsheet shown in block 5, once reached the spreadsheet optimization shows data collected at the end of all iterations. The optimization block 6 is in charge of modifying the data as often as necessary until you reach the desired criteria. In Fig 11 and Fig 12 shows the output data.

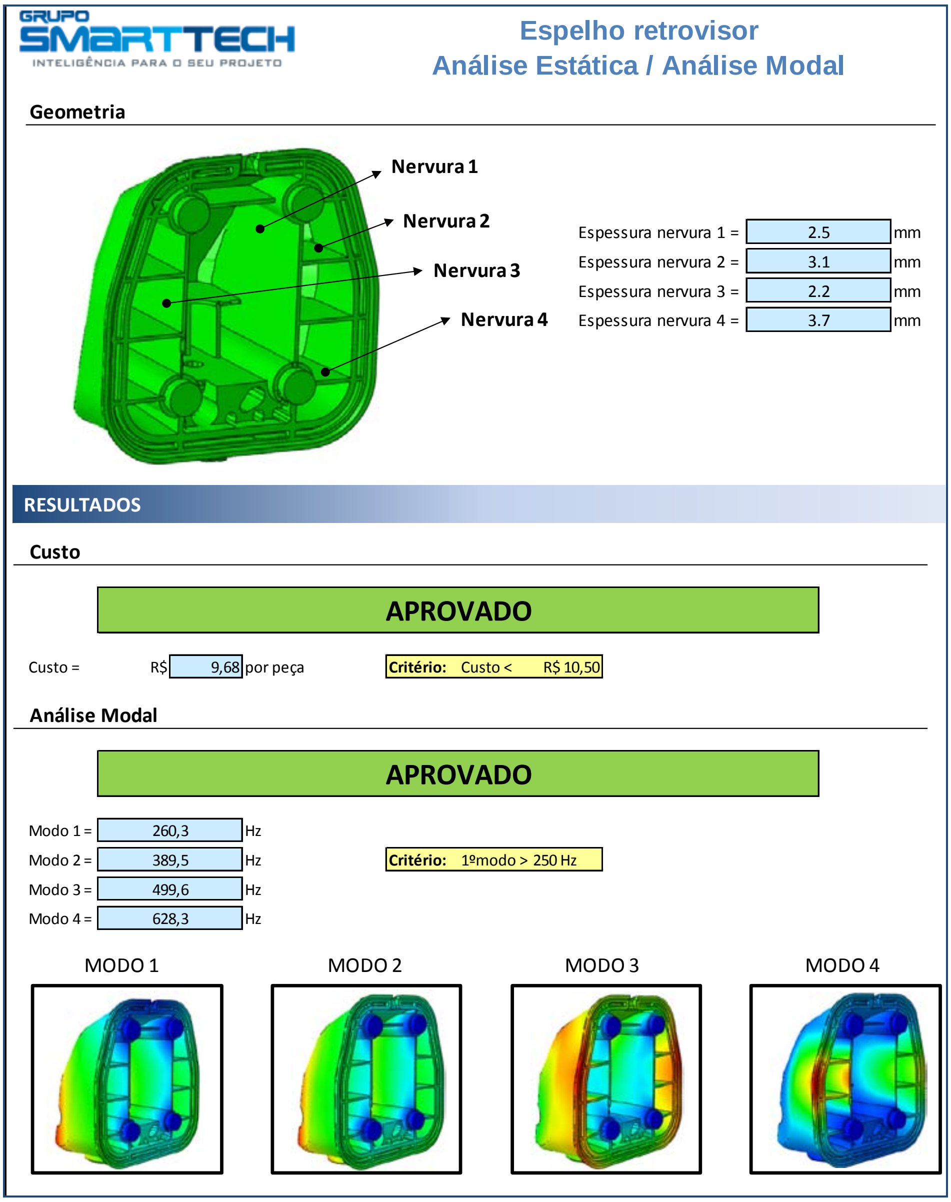


Fig 11. Excel spreadsheet automatically output

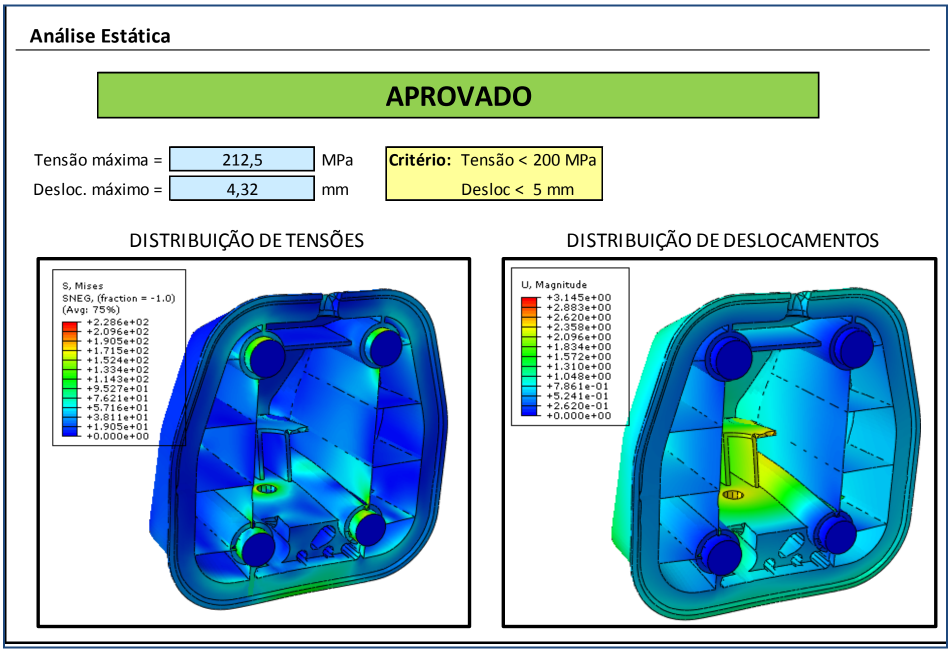


Fig 12 Excel spreadsheet automatically output

8. Material Condition.

In the injection process the material flows into the mold in a certain way, the way in which this occurs depends on several factors such as: The shape and thickness of the part to be injected, the number of injection points, the pressure with which it is injected, the temperature at which the material enters and the injection method used. All these and other factors affect the orientation of the material.

When we speak of orientation of the material we have to talk about the properties and these can be inter isotropic or orthotropic, the first one is when the material submitted by loads in different directions always respond the same way. In the case of orthotropic properties the material has different properties in each of these addresses. A typical case is the composite materials, for example carbon fiber may present in the form of fabrics with threads consecutively glued next to each other, keeping the matrix with resin. One can easily realize that if I apply force to the fabric in the axial direction of the wires will have a lot of resistance but if I do the cross section of the fibers are going to take off because only the resin support this union.

The same happens with the injection process, try to mimic this unidirectional fibers traveling within the mold cavities trying to fill all the gaps, when this cools the part to be ready but the material there will be left with specific guidelines that would lead to the other properties not be completely isotropic.

There are many authors and literature in which they have developed this theme very deeply. A few years ago it was difficult to determine the orthotropic nature of the parts. Today these types of simulations are easier to perform and give us a more accurate picture of what really happens to the parts.

In the majority of the structural simulations, the orthotropic nature of the material is not always taken into account and the use of isotropic properties is, in some cases, the most direct solution. In the majority of case these simulations represent the behavior of the part under a mechanical stress, but not in all scenarios.

We have noticed in some models where plastic parts are beginning to have considerable importance as structural parts that the differences in stress values between isotropic and orthotropic properties can be sometimes significant. This is aggravated when in addition injection processes are complex, as with the bumpers of cars.

One of the points of failure are the lines where there are Weld lines, these lines are the union of two fronts of material in the injection process which already has a lower temperature the fusion of material and that union is a line that may be causing a stress concentration. Software as Moldflow allows for this type of orientation and residual stresses by a simulation of injection and exported to Abaqus to consider these data in a mechanical analysis. This process can also be placed within the Isight process for better accuracy.

Only by way of example in Fig 13, 14, 15, 16, 17 shows a case where two simulations have been performed an isotropic material and another taking into account the orientations of material and residual stresses.

Fiber analysis and residual stresses

Analysis isotropic materials without residual stresses

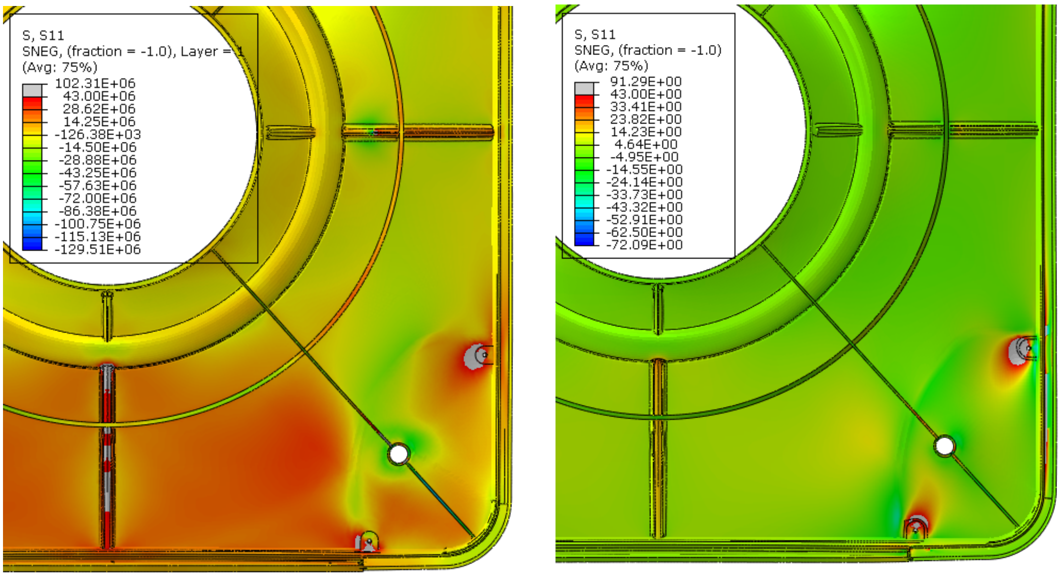


Fig 13. Diagram of principal Stress

Fiber analysis and residual stresses

Analysis isotropic materials without residual stresses

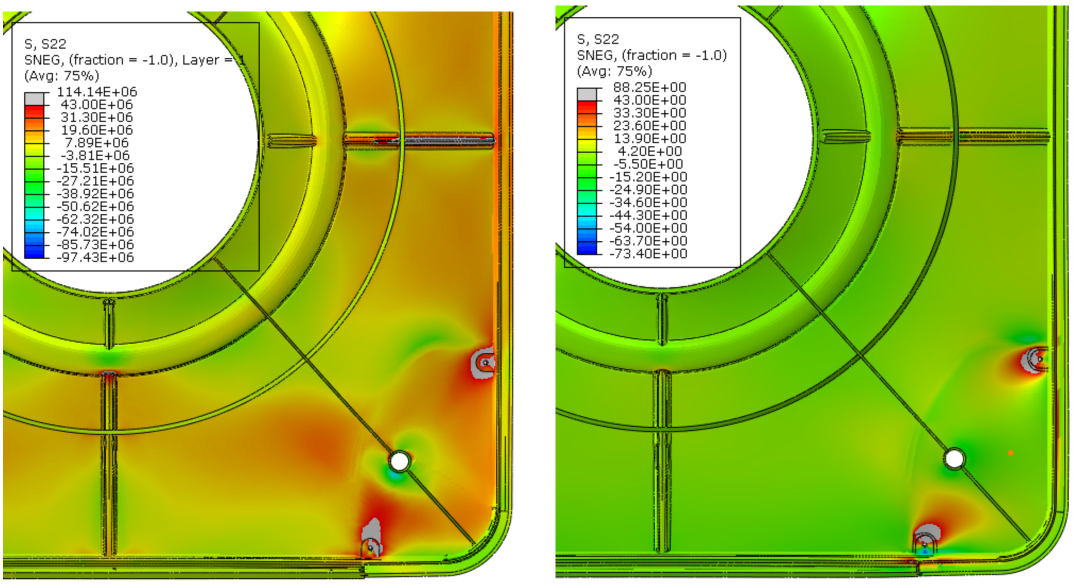
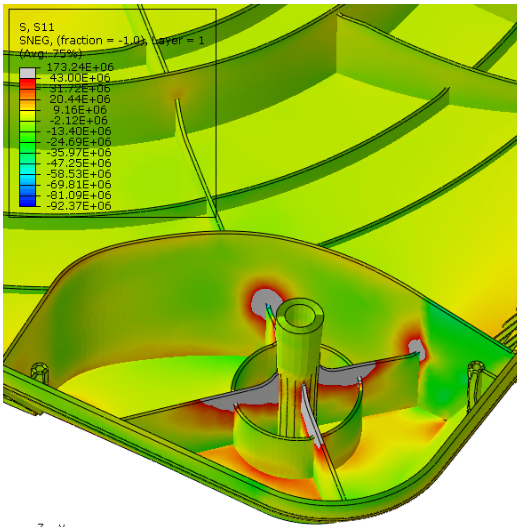


Fig 14. Diagram of principal Stress

Fiber analysis and residual stresses

Analysis isotropic materials without residual stresses



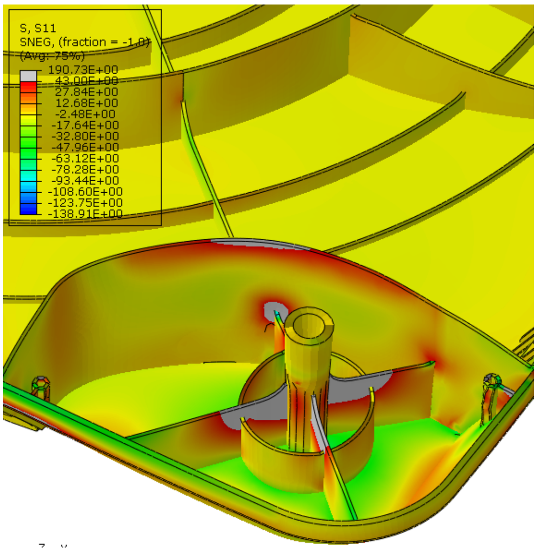
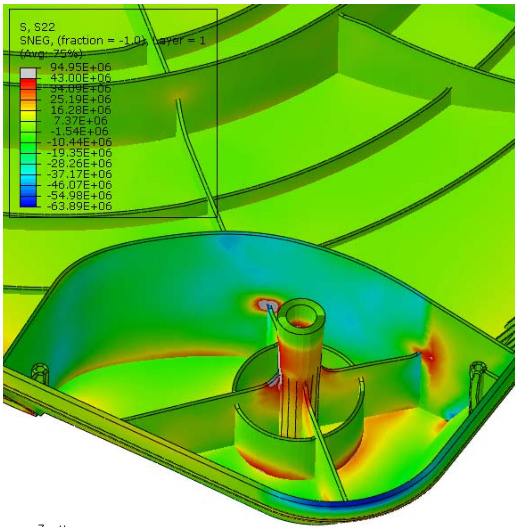


Fig 15. Diagram of principal Stress

Fiber analysis and residual stresses

Analysis isotropic materials without residual stresses



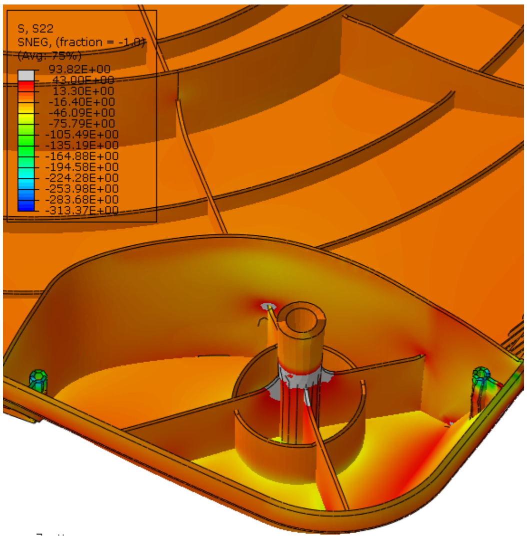


Fig 16. Diagram of principal Stress

Fiber analysis and residual stresses

Analysis isotropic materials without residual stresses

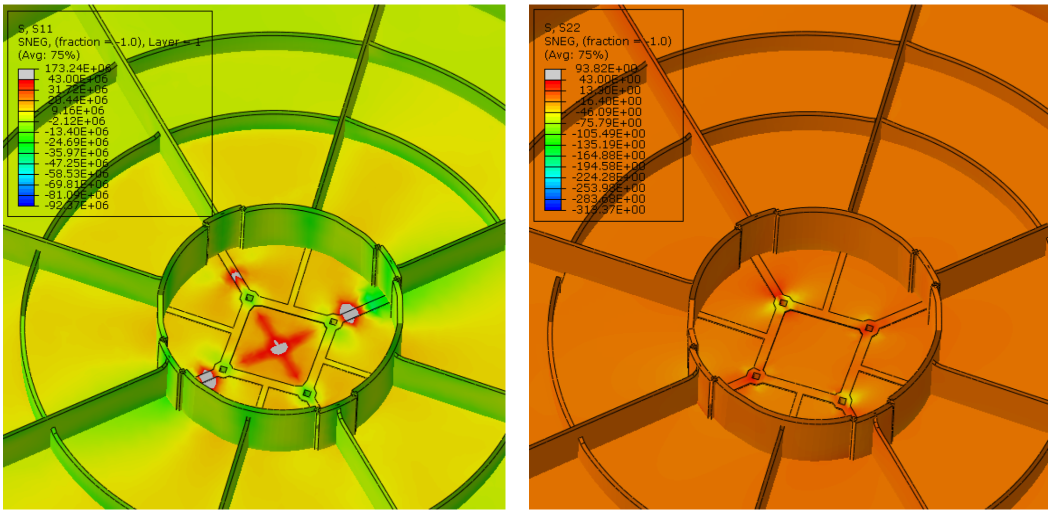


Fig 17. Diagram of principal Stress

9. Conclusion

We have performed different simulations using Isight technology and a reduction in the processing time has been noticed in all aspects. Due to the time needed for engineering design and simulation of manufacturing and structural systems, the automatic process of integration between different technologies has brought great importance to an optimized solution.

A scenario has been changed from a process of iterations that in some cases included many people who had to give their approval according to the area of application, to a process that was all integrated and managed by only one software.

As a consequence the time required for the simulation was higher because of the interactions needed, but it was also profitable and efficient in order to optimize, for example, the manufacturing costs without setting aside the design criteria.

In the example shown, the process is not only automatic but the user interface is easy to use. Even some companies that do not have strong technical teams are able to achieve good results with a good implementation of different tools integrated by Isight, and this way they can have a control they previously did not have with a good return-on-investment.

10. Acknowledgement

The authors gratefully acknowledge Eng. Jeovano Lima, Eng. Matias Meroniuc, Eng. Jorge Kuster, and Eng. Gabriel Curtosi.