

Multidisciplinary Design Optimization (MDO) with CAD and CAE

Keywords: Isight, CATIA V5, Automation, Design Optimization, CAD / CAE.

1. Title

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4. Abstract

Today, computational analysis is systematically used for the development of new models. However, traditional simulations and optimization studies require an exchange of data between the CAD and CAE applications that is extremely time-consuming and tedious. Improving CAD-CAE interoperability and automating the optimization process is a key to reducing model development time.

Via the Acc-u-Trans CAD Components and CAE Components available in Isight, a simulation process automation framework, we have coupled CAD and CAE to perform a variety of Multidisciplinary Design Optimizations, addressing both issues.

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5.2. Preamble

The following paragraphs highlight various Isight Use Cases realized by **Digital Product Simulation** and **Simulia**.

Integration of CAE processes within the design stages is the main issue of all cases which means that every simflow presented here is built upon a parametric CAD model.

Digital Product Simulation, specialist in CATIA V5 integration, has been working on Isight solutions for many years, developing various optimization simflows and methodologies. Depending on software environment, these may be implemented in various programming languages such as VB, Python scripting, or CAA.

The CAD models used in the following use cases are handled by the Acc-u-Trans CATIA V5 component developed by **TTI**. More details about this component are given below.

The CAD or CAE models mentioned in this paper may have been developed either in the course of industrial projects or for illustration purpose only.

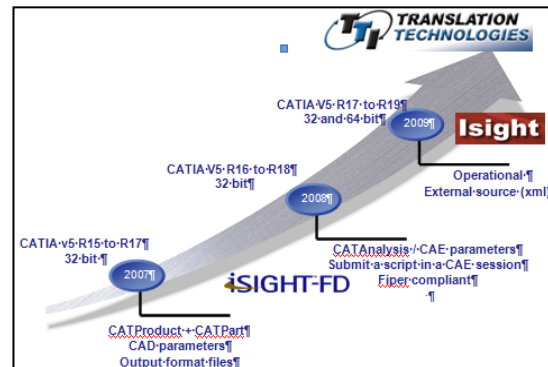
5.3. Component overview

5.3.1. CAD components

The purpose of a CAD component is to expose parameters, automatically modify parameters, and to save the updated model in a native or neutral CAD format compatible with the CAE system. The exposed parameters include geometric and mass properties. These parameters and the updated files can generate downstream CAE components.

Our CAD components are developed by our partner Translation Technology in Spokane, WA on the basis of their Acc-u-trans CAD product, providing seamless access to several leading platforms, supporting CATIA V5, Unigraphics NX, and Pro/ENGINEER software. By communicating through the APIs of the programs, scripts are not necessary; therefore CAD components can rapidly unlock large models to non-CAD experts.

Figure 1: CATIA V5



CAD Component development history

For example, the CATIA V5 component can easily dialogue with CATIA V5 to pilot parameters of CAD models or assemblies. It also has the functionality to support CATAnalysis files, exchange with embedded CATIA applications (extracting and submitting FEA parameters to drivers), and send a VBA script file to be executed into CATIA (automation of a complex time-consuming task such as the generation of an FE spot weld, etc.).

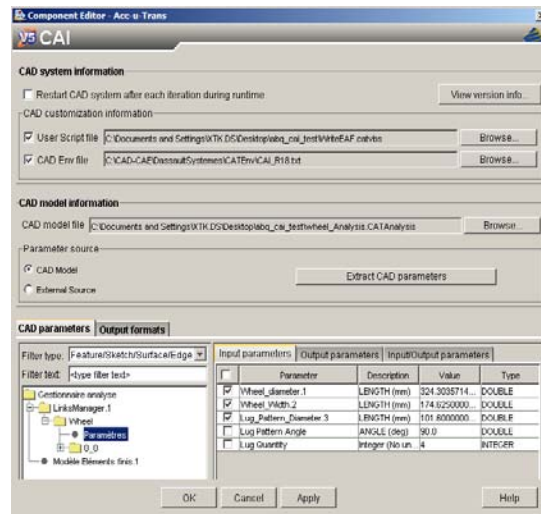


Figure 2: CATIA V5 CAD Component interface

5.3.2. CAE components

SIMULIA provides various CAE components, such as the STAR-CCM+, NASTRAN, LS-DYNA, ANSYS, MADYMO, Abaqus, etc, that work in the same way as the CAD components.

Other pre-processor or post-processor providing batch capabilities can be adapted for a multidisciplinary purpose. These tools are generally captured within simcode components to mimic our CAE components, which merge CAD and CAE information to generate input decks and also to extract outputs from the results files.

Coupling the Acc-u-trans CAD component with Isight creates an advanced tool, which facilitates:

- Interoperation between CAD modelling and computing codes,
- Implementation of coupling between CAD & CAE codes,
- Providing generic user interfaces that are user-friendly and efficient,
- Re-use of generated process,
- Post-processing, reporting and visualization.

5.4. CAD / CAE integration strategy

CAD/CAE integration is now acknowledged as one of the best solution to optimize products. Basically, designers want to analyze their products in the earliest stage of designs in order to reduce time consuming loops.

The main idea is to build the analysis model upon the CAD model in order to take advantage of associativity between these models. When the design is modified, the analysis model is automatically updated. It may be seen on some products as a good alternative to morphing approach.

Two solutions exist to achieve a CAD / CAE integration within an Isight simflow.

1. The first solution is to work with a native CATIA analysis model (CATAnalysis). Both mesh and pre-processing tasks are based upon CAD model or CAD associative entities (such as groups). In these cases, it is important to notice that CATIA V5 embedded solutions providing appropriate gateway are required to export the CATIA analysis model to a solver input file.

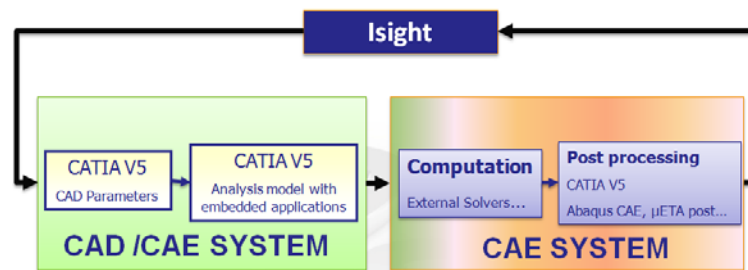


Figure 3: CATIA integration with embedded CAE applications

2. The second solution is to export native CAD models, then automate the pre-processing tasks in an external CAE application. This can be achieved under the condition that these applications:

- are able to read native CATIA V5 model without any loss,
- provide automation capabilities.

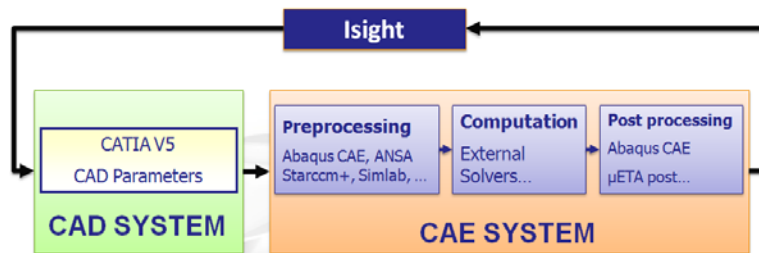


Figure 4: CATIA integration with external CAE application

The following paragraphs and Use Cases highlight these two kinds of integration.

5.4.1. Integration through embedded CATIA V5 applications

5.4.1.1. Abaqus For Catia (AFC) integration

AFC allows users to define their Abaqus analysis model within the CATIA V5 CAD and analysis environment. To some extent, it covers capabilities of Abaqus CAE and has now reached an acceptable level of capability, allowing it to accommodate and define complex models. In one hand, parametric and associative models can be built and in the other hand Simulia provides many APIs for automating various user processes.

Since 2003, DPS has been asked by its customers to define specific methodologies in AFC. Most of these projects led to the integration of dedicated applications within CATIA V5 often built upon parametric models.

Therefore, a possible advanced use of Abaqus For Catia is to enable optimization on parametric models driven by a PIDO solution.

From a technical point of view, the integration of embedded CATIA V5 applications is made through specific VB scripts driven by the CATIA V5 component. DPS acquired a great knowledge in that field and consequently worked with Simulia and TTI providing appropriate generic scripts for several use cases.

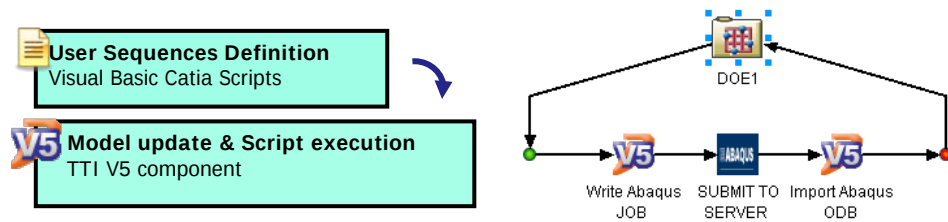


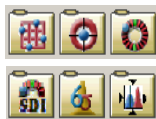
Figure 5: A typical AFC integration with CATIA V5 component

A typical computation AFC process consists in three components:

→  The first CATIA V5 component modifies CAD and CAE parameters, updates the model and executes a generic VB script to export the Abaqus input deck from AFC.
Write Abaqus JOB

→  The OS Command component launches Abaqus computation and returns the results file (the .odb binary file).
SUBMIT TO SERVER

→  The second CATIA V5 component executes a second generic VB script to imports the .odb file within CATIA V5, updates the model, read the responses and feeds up a design driver.
Import Abaqus ODB



This process can be encapsulated in various Isight design exploration strategies (Design of Experiment, Optimizers, quality methods, etc.), wherein design drivers adjust the design variables and review the outputs until the requirements are met.

This common process has been initially validated with a simple model, before being re-used with more complex models at Peugeot Citroen (a French manufacturer). This kind of process has been as well used at VOLVO truck to respond to an engineering problem. Due to confidential reasons, the integration process is mainly explained.

The objective was to understand the parameters influence on a crack growth between the engine valves of a truck under thermo-mechanical effects.

The parametric engine has been built by Karim LAKHAL (from Dassault systemes), the FE model by Kamel TERKI (from Simulia) and the optimization portion by Frederic KRABCHI.

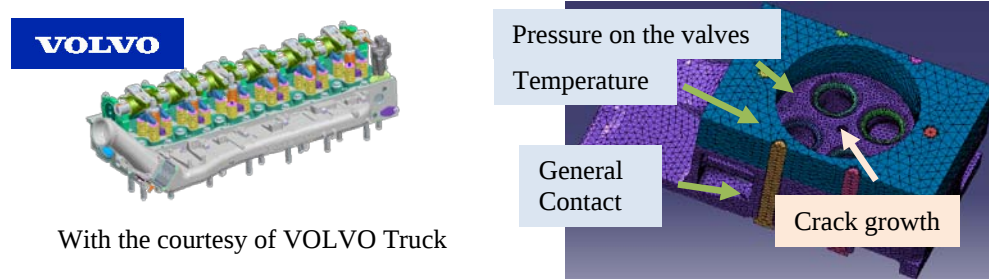


Figure 8: Parameterized engine model

Figure 9: Engine FE model performed with AFC

The complete process is driven by a Microsoft Excel spreadsheet, wherein all input data and final results are written.

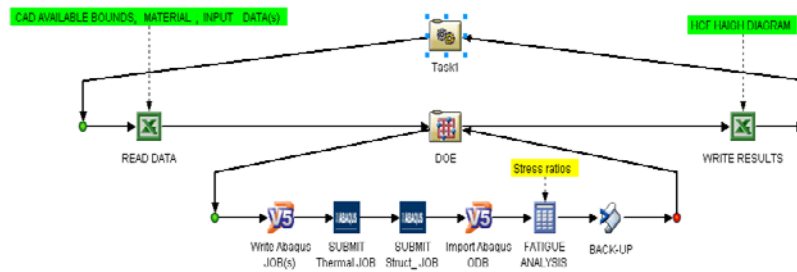
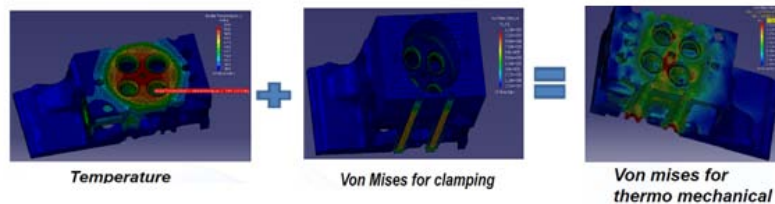


Figure 10: Coupling AFC simflow

As represented in the figure just above; two Abaqus input decks have been exported from CATIA to firstly compute a thermal job, and afterwards a structural analysis using the results of the first computation. A fatigue study is therefore realized based on the results previously generated.



5.4.1.2. FEM Utilities / Fluent integration

Based on the work done by Mickael GUERIN (DPS), the purpose of this Use Case is to demonstrate the ability of Isight to drive automatically a complete fluid computation process built on a simple parametric CAD model of a bend pipe.

Today, this kind of study can be realized through a morphing approach but remains limited by mesh distortion. By working on a CAD model and an associative mesh, a larger range of designs can be studied in one pass of optimization.

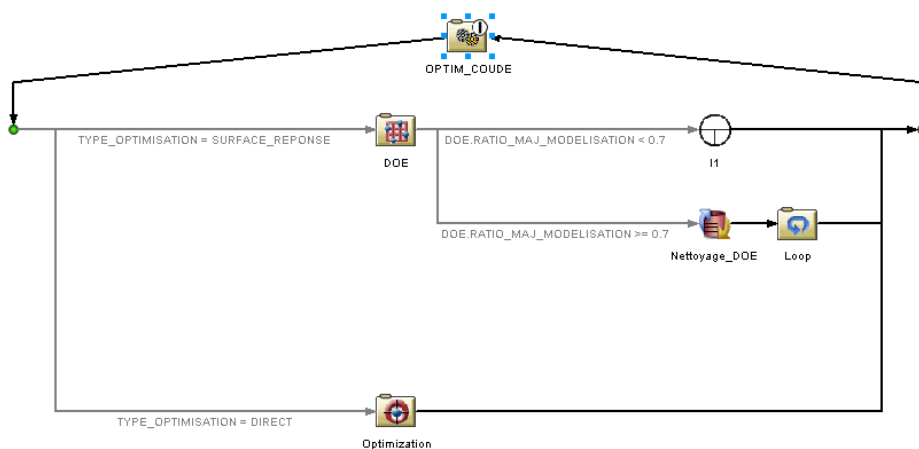


Figure 11: Bend pipe optimization simflow

The objective here is to optimize the form of a bend pipe to minimize the pressure loss in the pipe.

The use case consists of:

- A CATIA V5 parametric CAD model and associate 3D mesh
- The specific use of DPS Nastran Gateway available in FEM Utilities to perform the export of the CATIA V5 mesh in Nastran Bulk Data format (mesh and appropriate analysis sets in the model).
- A call to T-Grid to generate Fluent input deck from previously exported Bulk Data file.
- A Fluent analysis to compute the pressure loss.

Spline coordinates of the bend pipe are parametric. Five geometric points have been select to drive the bend pipe shape.

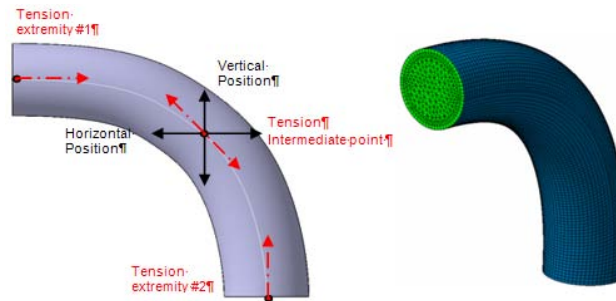


Figure 12: Bend pipe parametric model

As shown below, the chosen design parameters allow a wide range of possible design that would not be admissible with a morphing approach.

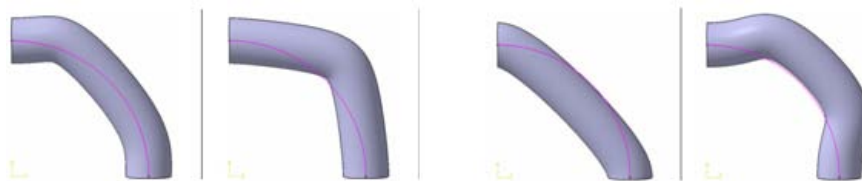


Figure 13: Possible designs

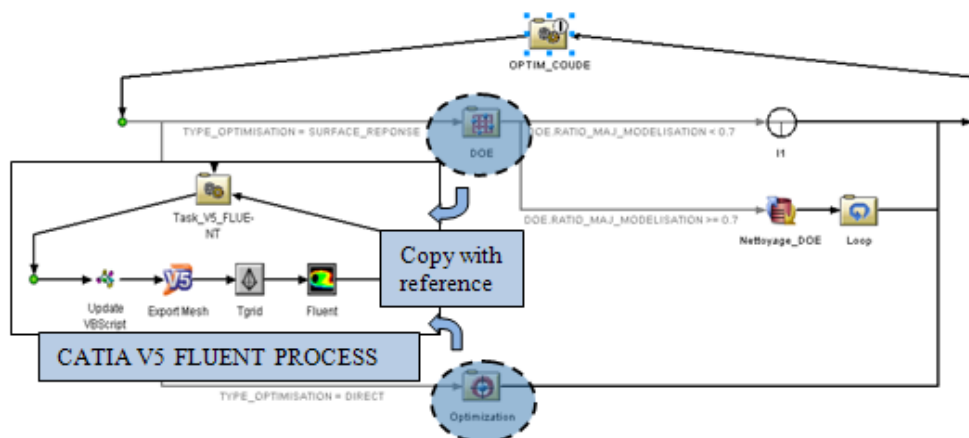


Figure 14: CATIA V5-Fluent process

The computation process consists of four components:

-  A Data exchanger component parses the user script executed by the CATIA V5 component to use specific information Case ID and FE model name.
-  The CATIA V5 component modifies design parameters, updates CAD model and exports an associative mesh through appropriate script.
-  This simcode component generates a Fluent input file.
-  This simcode component launches the Fluent computation and parses output results.

Another purpose of this use case was to identify the best identified practices. Some of these best practices are discussed below.

Best practice 1

The simflow should allow the User to either perform an optimization based on a DOE and an approximation of the problem or to perform a direct optimization. Every branch of the simflow should reference the same encapsulated process.

Best practice 2

When using a DOE approach, the simflow should automatically eliminate designs which are not acceptable, i.e. those for which CAD model or meshes cannot be updated.

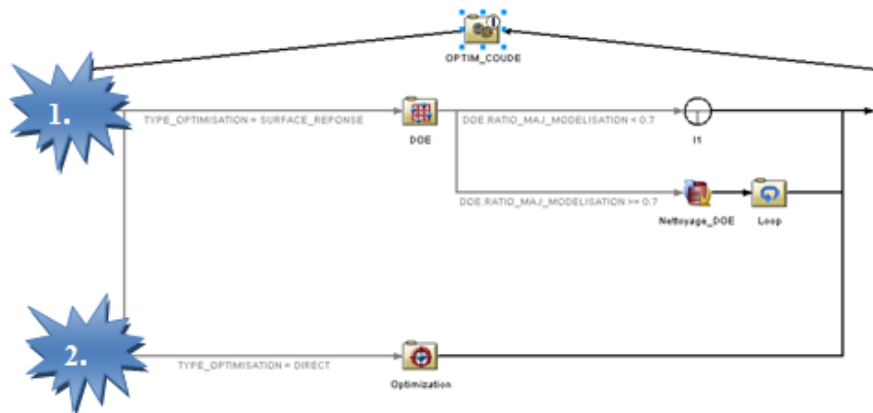


Figure 15: Two branches of optimization and DOE validation

Best practice 3

The optimization sequence should start with a genetic algorithm to reach the global optimum. This given optimum will be the initial point for a second gradient based optimization.

Once optimization is completed, an analysis run on the optimum design is performed. If the variation between the approximation model and the analysis run is within the range of acceptance, the optimization is validated. If not, the performed analysis run is added to the previous DOE and a new approximation model is computed.

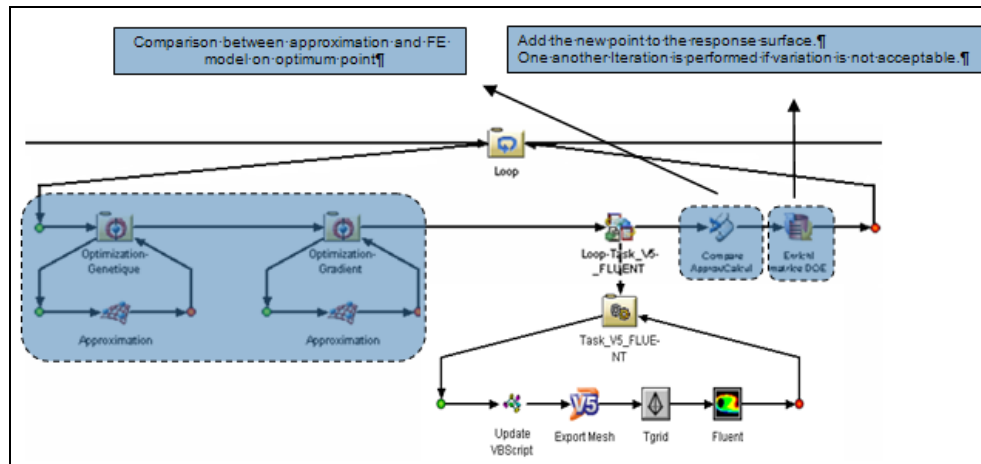


Figure 16: Approximation based optimization loop

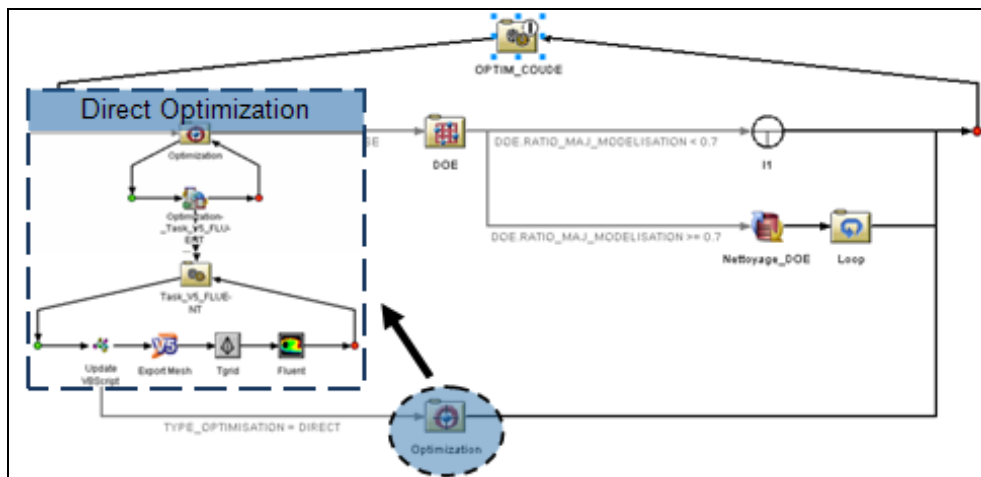


Figure 17: Direct optimization branch

Some results are given below:

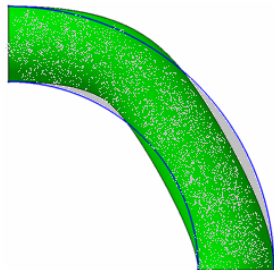
	Pressure Loss (Pa)	Benefit (%)	
Objective	Min		
Nominal	438.14		
Optimum FE	410.41	6%	
Optimum Approx.	411.30		
FE. / Approx.	0.22%		

Figure 18: Nominal (blue) and optimum pipe (green)

5.4.2. Integration through external CAE applications

5.4.2.1. Abaqus CAE Integration

Abaqus CAE is one of the most used pre-processors for Abaqus simulation, worldwide. It gives Users access to the most up-to-date Abaqus capabilities.

In 2008, Simulia provided CATIA V5 Users the CATIA Associative Interface (CAI), an associative between the CATIA CAD model and Abaqus CAE. In that context, any of the features created in Abaqus/CAE (partitions, loads, material, boundary conditions, sets, etc) are regenerated each time the modified CATIA model is imported from CATIA V5 to Abaqus CAE.

The objective here is to resolve the following engineering problems of a parametric wheel:

- **To understand the wheel design input to output influences with respect to a static analysis. The desired result is to minimize Mass, subject to keeping the Von-Mises stress below the yield stress of the material (110 Mpa).**
- **To perform a mesh sensitivity study prior to the optimization to add quality in our model.** It is important to notice that most of the time this sensitivity study is disregarded in optimization loop and therefore produced questionable design quality.

A) Pre-requisites

1. Parametric CATIA model for geometric manipulation,
2. Abaqus CAE plug-in to export the assembly file (.eaf file) from CATIA V5,
3. Abaqus CAE for FE model building and Abaqus implicit solver for simulation,
4. Isight for process integration and design optimizations.

B) Test case description

1- CAD model

Five parameters drive the parametric wheel such as the wheel diameter, the wheel width, the number of lugs, the lug diameter and the lug pattern angle.



Figure 19: Parametric wheel done with CATIA V5

When changing these parameters values, the model will be updated accordingly. Furthermore, if parameters values are not within their respective bounds, the CAD model won't be updated by CATIA.



Figure 20: Wheel model with possible designs

2- Structural analysis

Pre-processing and post processing tasks are done within Abaqus CAE.

The wheel is modeled with second order tetra elements (C3D10M) with a meshing size of 15mm. A skin is also extracted and meshed with membrane elements (M3D6) of 1E-6mm to recover the Max Von Mises stress.

The internal diameter is clamped and a uniform pressure of 17Mpa is applied on the external transversal face.

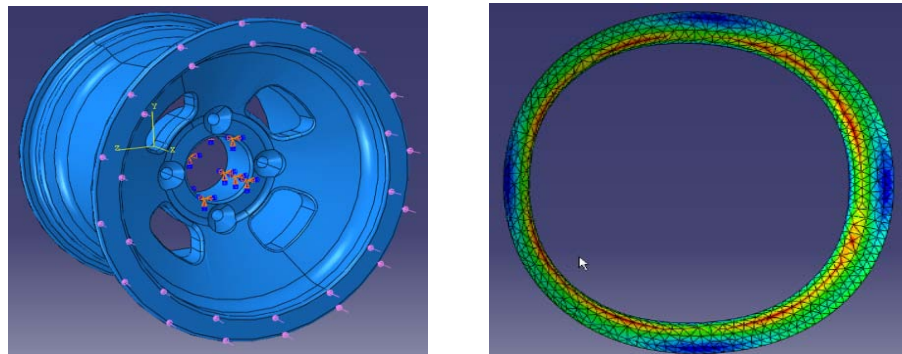


Figure 21: Boundary conditions, loads and post-processing area (extracted skin)

3- Process integration

Isight has been used to link CATIA V5 model and Abaqus CAE.

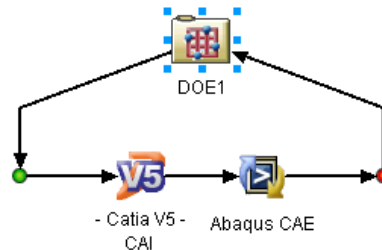


Figure 22: CATIA V5 to Abaqus CAE simflow of a wheel

The CATIA V5 component does the following tasks:

- Modifies the input values of the CATIA model
- Saves the updated CAD Model,
- Executes a generic VB script to export an assembly file (.eaf file) and a 3dxml file.

The updated CAD model and the .eaf file are moved by Isight to downstream CAE component.

The Abaqus CAE component is a simcode, which is used to parse I/O files and to execute commands, in batch mode, included in a python script.

The python script is generated automatically by Abaqus CAE, which has recorded all the operations performed by a User in a previous sequence. It does the following steps:

- Open Abaqus CAE with the Abaqus/CAE model database file (.cae file)
- Import the .eaf file, which uploads as well the updated CATIA model. The .cae file is therefore automatically regenerated
- Modify the pressure value and the meshing size
- Execute the Abaqus job and import the associated results file
- Export the Max Von Mises stress on a report file and a 3dxml file to display the results.

Users can therefore parse within the simcode component the python script and the report file to expose the desired I/O parameters to Isight.

4- Sum up of the design problem

The design exploration strategy is based on a DOE using an Optimal Latin Hypercube (OLH) Technique with 50 points.

The Design Variables (DV) and Outputs are represented just below, as well as a summary of the design problem.

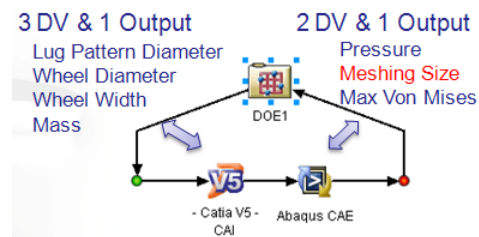


Figure 23: Selected Design Variables and Outputs parameters

DOE1					
Define the problem you are trying to solve by specifying bounds and objectives for parameters. This information will be used to configure the design parameters used in this DOE component.					
10 of 10 rows are shown					
Parameter	Mode	Lower	Value	Upper	Objective
Unmapped subflow parameters					
Mass@Wheel			13929,44472		minimize
VON_MISES_MAX			106,401	110,0	
Lug_Pattern_Diameter_3@Paramètres@Wheel		96,52	101,6	106,68	
MESH_SIZE		10,0	15,0	20,0	
PRESSION		12,0	17,0	22,0	
Wheel_diameter_1@Paramètres@Wheel		288,0	320,0	352,0	
Wheel_Width_2@Paramètres@Wheel		150,0	250,0	200,0	
Run #			0		

Figure 24: Summary of the design problem

5- Results

Some results are shown below.

An estimated optimal design is provided to Users (highlighted in green in the history tab).

Failed runs are also specified with the Icon . When using the CATIA V5 component, it corresponds to a set of parameters which can't update the CAD model.

DOE1						
Run Path			Parameters for all iterations (Done)			
			Wheel_diameter_1@Parameters@Wheel	Wheel_Width_2@Parameters@Wheel	Mass@Wheel	VON_MISES_MAX
✓	1	5	336,3265306	192,8571429	13081,1627	133,492
✓	1	6	320,6530612	178,5714286	11883,1731	95,3003
✓	1	7	311,5102041	196,9387755	11948,76856	105,756
✓	1	8	332,4081633	185,7142857	12671,41011	69,2244
✓	1	9	299,755102	188,7755102	11153,87943	95,3032
✗	1	10				
✓	1	11	346,7755102	166,3265306	12778,41012	95,3284
✗	1	12				
✓	1	13	304,9795918	155,1020408	10511,5852	103,653
✗	1	14				
✓	1	15	348,0816327	194,8979592	13756,03162	135,616

Figure 25: List of results for all iterations

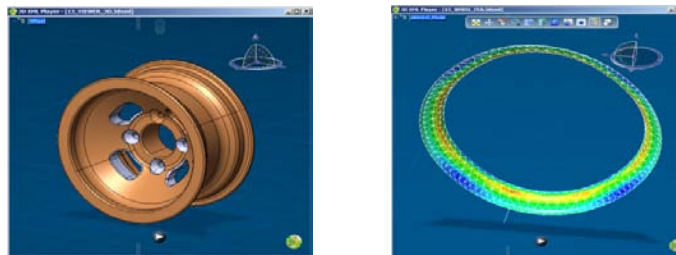


Figure 26: Estimated optimal design displayed with 3dxml files from ISIGHT.

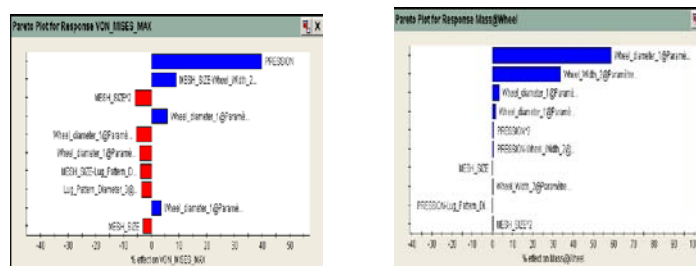


Figure 27: Pareto plot graphs

An approximation model has been built from the DOE results. This helps to observe the influence of inputs on outputs. Indeed, the meshing size influence can be analyzed with other I/O parameters for quality purposes.

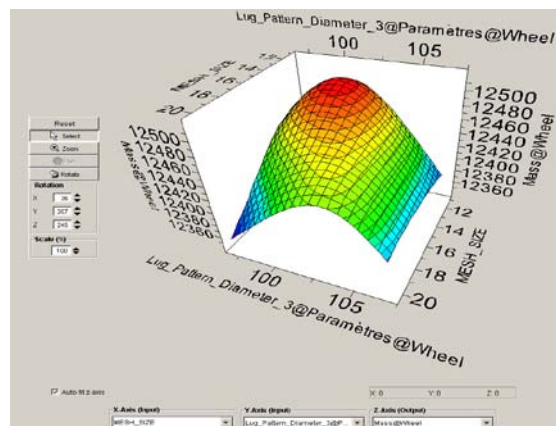
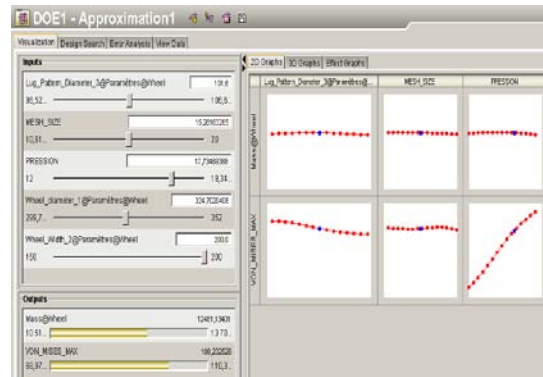


Figure 28: 3D approximated model

5.4.2.2. STAR-CCM+ Integration

Based on the work done by Dwayne Dutton, Jason Pyles and Malik KALYTUPOV (from SIMULIA US) presented *at the STAR Global Transportation Forum December 8th 2009*, we simplify the process linking CATIA V5 to STAR-CCM+ by the use of the CATIA V5 component, which eliminates the need for non generic script files and design tables.

This demonstrator has been initially requested by **Chrysler CFD group** for in house training, because Chrysler engineers felt that manual iterations were too time consuming and may not result in optimal designs.

The objective is to Minimize Flow Loss Optimization Study of a parametric Exhaust Manifold performed within CATIA V5.

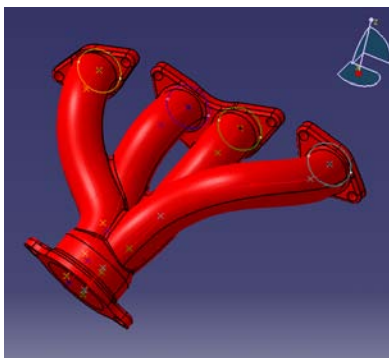


Figure 29 : Parametric Exhaust Manifold done with CATIA V5

A) Requirements

1. Parametric CATIA Model for geometric manipulation
2. STAR-CCM+ for CFD model building and pressure drop simulation.
3. Isight for process integration and design optimization.

B) Process integration

Isight has been used to integrate/automate parametric CATIA model and STAR-CCM+ analysis.

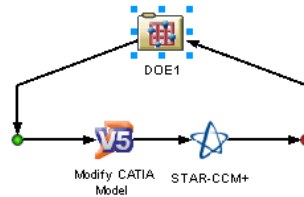


Figure 30: CATIA V5 to STAR-CCM+ simflow of an Exhaust Manifold

- 1) Values passed to/from CATIA using the CATIA component.
 - Geometry based on four spline curves, one for each runner
 - Spline coordinates are parametric and bring together in a parameter node within the CATIA tree specification
 - The CATIA component modifies the Input parameters, updates the model and saves it into a native format file before sending it to the CAE component

- 2) STAR-CCM+ analysis executed via STAR-CCM+ component and user-created macro.

The STAR-CCM+ component extracts all inputs and outputs from sim file, and User selects which parameters to expose to Isight.

A user macro is used to generate automatically the FE model, replaying the following steps :

- Import geometry, update inputs,
- Strip unneeded features,
- Fill holes, apply boundary conditions,
- Create monitors for outputs of interest,
- Generate mesh and solve.

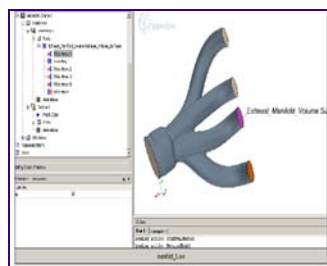
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Figure 31: Steps in STAR-CCM+ macro

3) Isight manages all parameters and files and controls the design exploration.

The **Design exploration strategy** is based on the following:

- Sample design space using DOE.
- Build approximation model.
- Optimize on approximation model.
- Re-run analysis at approximated optimum.

4) Results:

- The process integration doesn't require any CAD script to drive the CAD model
- Pressure reduced by 11% from initial design.
- Approximation total error was 1.3% at optimum, but individual error ranged from 0.4% to 5.3% - Additional sampling points would reduce error

Approximate vs. Actual		
	Approximate	Actual
Pipe1 Length (mm)	283.3500781	283.384
Pipe2 Length (mm)	213.9991208	214.084
Pipe3 Length (mm)	204.3235468	204.35
Pipe4 Length (mm)	222.8319708	223.563
Pressure 1 Monitor	19.26608083	19.18353
Pressure 2 Monitor	12.45737098	13.16868
Pressure 3 Monitor	14.5067044	15.00333
Pressure 4 Monitor	13.48730645	13.09317

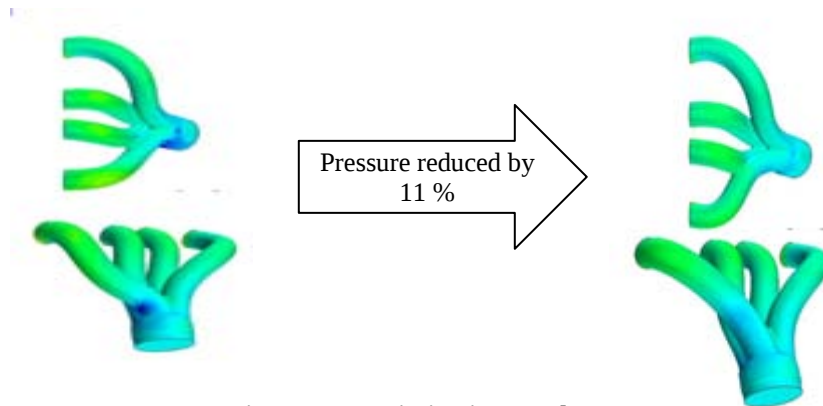


Figure 32: Optimization results

5.4.2.3. ANSA Integration

We proposed to integrate some BETA-CAE products for CAE pre-processing and post-processing within the Isight platform and its components.

A methodology was created around a use case to illustrate such a process. The model comprises of a hierarchy of CAD-CAE features such as parts, meshing, loads, boundary conditions, and post-processing. Information relating to both design and analysis can be specified and modified. The specified information from the design process is used to activate relevant CAE analysis tasks, thus supporting integration from the CAD to CAE process.

If any of the specified design constraints are not satisfied from the CAE results, the initial model can be modified and the CAE analysis executed again. To couple CAD and CAE systems, CAD and CAE components within Isight have been used.

Description of a test case

The CAD model is a 3D CATIA V5 parametric HP Cover model. The aim of this part was to develop a methodology according to the working hypotheses and the problem definition.

Working hypothesis:

- ***Boundaries and loads can be modified by the parameterization***
- Preprocessing and post processing within ANSA and µETA
- Parse specific cards after the export of the FE model from ANSA (e.g., materials).
- Computation with Abaqus implicit
- To preserve the mesh quality during the process

Problem definition:

The design problem is to understand the influence of three design variables of the model on outputs as mass, Von Mises stress and natural frequency. Furthermore, during the process the mesh quality had to be preserved.

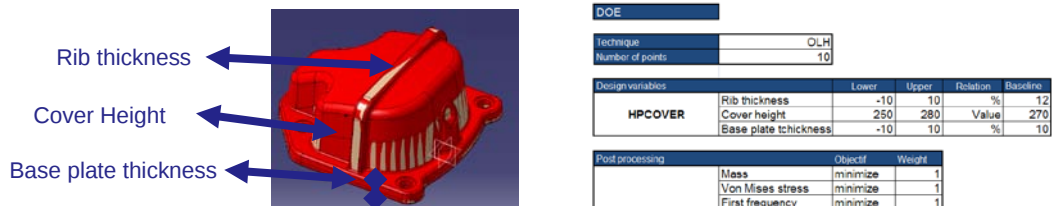


Figure 33: Design variables of the model

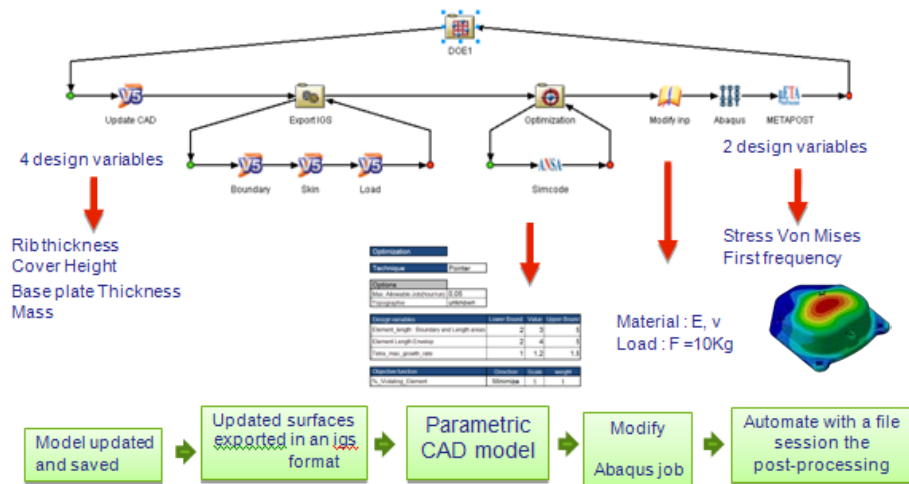


Figure 34: Linking CATIA V5 to BETA-CAE within Isight

Methodology

The parametric CAD model is split into several CATPart files updated with the CATIA component. Once exported, these surfaces are placed and constrained in ANSA as a pre-existing file and an ANSA script rebuilds automatically the geometrical model, updates the FE model and exports it an ABAQUS format file.

When the simple loop is finished, the DOE loop becomes easy to put in place.

5.4.3. Crankshaft balancing optimization

This part is based on the work done by Xavier DUGROS and Mickael GUERIN (from DPS).

Crankshaft development raises many issues in the global development of a new engine such as dynamic, strength or acoustic behaviors. Therefore, engineers must find the best balance between these many requirements while decreasing the mass of the system.

One solution to answer this knotty problem is to quickly iterate on virtual models based upon more or less simplified parametric CAD models. Once main design parameters have been defined and implemented into a CAD model, it is possible to evaluate their main effects and find optimum solutions.

Digital Product Simulation has developed for its customers a global simflow within CATIA V5 based on a parametric crankshaft, in-house excel calculation worksheet and multidisciplinary Abaqus simulations.

The global process is illustrated below:

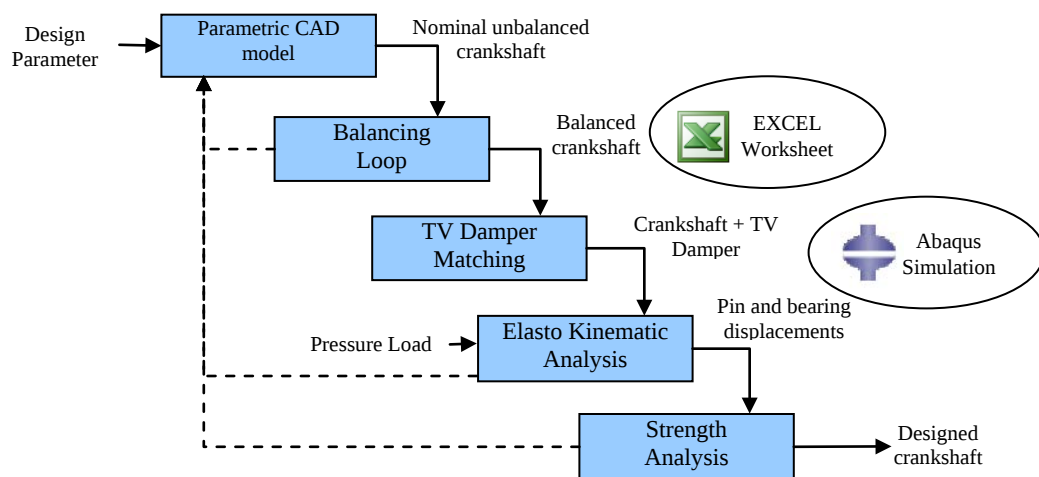


Figure 35: Design process

This paper deals with the first step of the global simflow which is the static and dynamic balancing of the crankshaft. No external solvers are needed in this simflow. All formulae are defined in Excel worksheets. Nevertheless, this simflow is a perfect example of a CAD driven design.

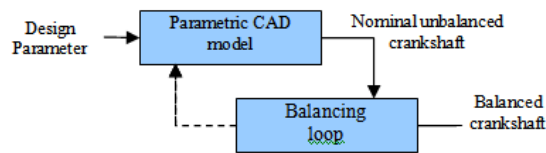


Figure 6 Balancing process

The next part of the process, not developed in this paper, consists of several Abaqus simulations. The full analysis model, associative to the CAD model, is built within CATIA V5 and the Abaqus input file is retrieved via to Abaqus For CATIA and the appropriate scripts.

First of all, it is important to notice that Digital Product Simulation developed a fully parametric engine model with an associative analysis model. In one hand, such models allow designers to quickly iterate on different designs, and In the other hand, for each design, it systematically provides CAE engineers an analysis model for some FE analysis.

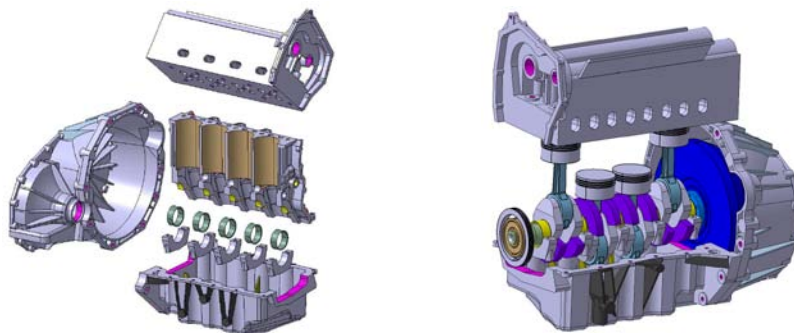


Figure 37: Parametric engine model (3 / 4 cylinders) developed by DPS

As shown on the right, it was completed by a dedicated CATIA V5 workbench allowing a fully parametric crankshaft to be built. Thanks to this workbench, users can easily build parametric CAD models of crankshaft.

For the purpose of this paper, the balancing optimization study was done on a crankshaft designed for a four cylinders engine in line.

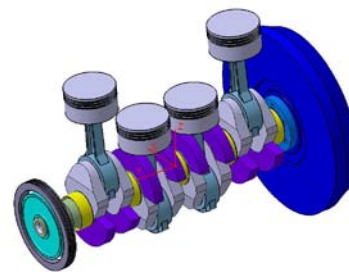


Figure 38: Parametric crankshaft

Then, the balancing optimization can be realized within Isight using Excel, the CATIA V5 component and the appropriate scripts.

Bielles				
CulG	Masse (Kg)	Bielle1	Bielle2	Bielle3
		5.729E-01	5.729E-01	5.729E-01
	x _G (mm)	0.000	0.000	0.000
	y _G (mm)	132.000	44.000	-44.000
Coordonnées B	z _G (mm)	82.530	-7.470	-7.470
				82.530
	Entraxe L (mm)	130.000	130.000	130.000
	x _B (mm)	0.000	0.000	0.000
	y _B (mm)	132.000	44.000	-44.000
	z _B (mm)	175.000	85.000	85.000
				175.000
	L (mm)	92.470	92.470	92.470
	m _B (Kg)	4.075E-01	4.075E-01	4.075E-01
	m _B (Kg)	1.654E-01	1.654E-01	1.654E-01
Pistons (avec Axes et Segments)				
	Masse m _p (Kg)	Piston1	Piston2	Piston3
		1.179E+00	1.179E+00	1.179E+00
				Piston4
				1.179E+00
Masses alternatives (m _{cr} + m _b)				
	m _{cr} (Kg)	Cylindre1	Cylindre2	Cylindre3
		1.345E+00	1.345E+00	1.345E+00
				Cylindre4
				1.345E+00
Contrepoids				
		Contrepoids 1	Contrepoids 2	Contrepoids 3
				Contrepoids 4
				Contrepoids 5
				Contrepoids 6
				Contrepoids 7
				Contrepoids 8
				Contrepoids 9
	Volume (m ³)	0.000E+00	4.894E-05	9.660E-05
	Masse m _c (Kg)	0.000E+00	3.611E-01	4.448E-01
	Epaisseur (mm)	1.864	9.322	-6.610
				-2.881
				-6.271
				0.558
				-7.627
				-10.099

Figure 39: Extract of Excel spreadsheet

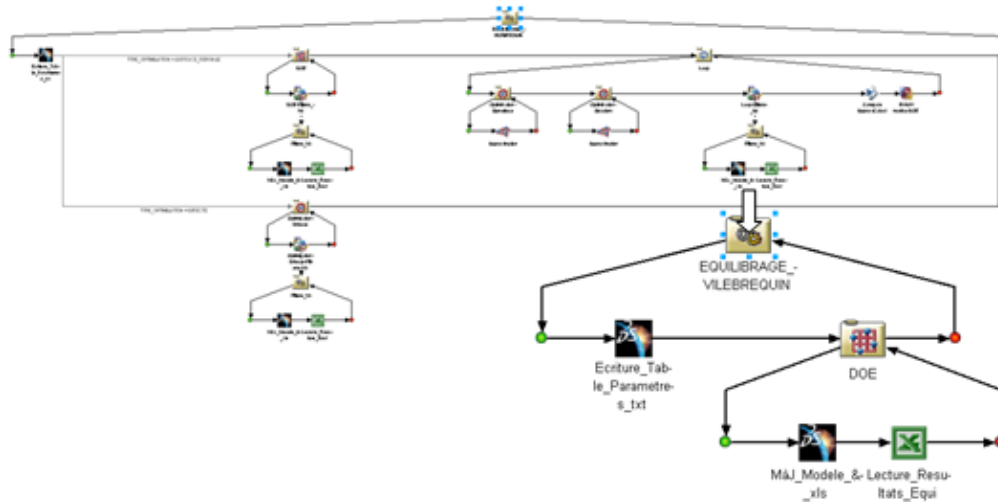


Figure 40: Simflow used for balancing optimization

This brief description of the simflow demonstrates the ability to implement the crankshaft design process in Isight based on a parametric CAD model. By providing specific components

such as Excel and CATIA V5 components, Isight allows engineers to quickly develop complex simflows that capture know-how and best practices.

Once published, designer can get access to the appropriate design tools to allow them to optimize and enhance their products.

5.5. Conclusion

We have demonstrated in this paper:

- ⊕ An advanced CAD interface (component) in the context of a rapid CAD-to-CAE process.
- ⊕ CAD and CAE interoperability issues can be solved in many different ways. One way is to use analysis capabilities of CATIA V5 and embedded gateway. Another way is to use an external CAE application to read the updated CAD model. Several use cases showed the ability of the component to feed CAE simflow with a properly updated CAD model.
- ⊕ The resulting simflow enables multidisciplinary design exploration studies.
- ⊕ The ability of Isight to easily handle design optimization or sensitivity analysis on parametric CAD and CAE models.
- ⊕ Isight enables to add quality in our simulation models (the mesh quality for FEA prior to the optimization studies).

As with every automated numerical simflow, script development is the main issue. To take full advantage of Isight capabilities, the mission of Digital Product Simulation is to provide its customers many generic scripts, especially in CATIA V5 environment.

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