

OPEN-Abaqus: New approach for coupling Design Of Experimentations and Abaqus solver

Cyril SAILLEY

Digital Product Simulation

Philippe DAUSSE

PSA Peugeot Citroën

*Abstract: Abaqus is used by PSA Peugeot Citroën car company in order to dimension and validate engine and chassis components. As physical parameters influence the mechanical resistance, these parameters have to be chosen into the right range for a reliable product design. The PSA solution is to use the **design of experiments (DOE)** directly & easily on Abaqus models in order to deliver better-quality products through accelerated evaluation of design alternatives. The users define the parameters of the Isight simulation process flow in the SIMULIA Execution Engine Webtop. This application is called OPEN Abaqus.*

OPEN Abaqus executes the whole “DOE” on PSA standard computing tools. Into the Webtop – a user friendly interface intranet input data - the user has to: Firstly, choose the right parameters and introduce them into the Abaqus input data file. Secondly, define the range of parameters variation and the output variable. Thirdly, choose through three proposed DOE: two-levels factorial fractionnary, NOLH, or user defined. At this stage, the Isight workflow is ready to be launched. It means that all the Abaqus jobs defined by the DOE will be computed. At the end of the workflow, the output data are automatically processed into a report. This report includes the graphs related to each parameter influence as well as their interactions. OPEN Abaqus was deployed in early 2010. First applications included screwed assemblies and brake pads.

Keywords: Design Optimization, Experimental Verification, Optimization, Output Database, Postprocessing, Probabilistic Design, Design of experiment.

1. Introduction

Abaqus is used by PSA Peugeot Citroën in order to dimension and validate engine and chassis components. Usually, these models are based on the theoretical value of each design parameters. OPEN-Abaqus allows users to run Design Of Experiments -DOE- and reliability's approaches on these parameters instead of keeping only the theoretical value. This DOE is based on Abaqus solver with a full automated method and pilots all numerical parameters which can be written into an INP file.

A user friendly interface based on Microsoft Excel 2003 allows users to choose the type of DOE, the design parameters and the response which will be evaluated.

OPEN-Abaqus submits all jobs constituting the DOE. Then it evaluates and sorts effects of the factors -input parameters- and their interactions to the response -output parameter-.

This approach consists to classify each input parameter according to the table below, the final goal being to find the design most robust for the studied model.

Parameter...	Controllable	Non controllable
Dominating	Design optimization	Need to control
Non influent	Liberty of design	Stop control

Table 1: Guideline for design

2. Synopsis

This presentation will give you some information about:

1. Perimeter of use of OPEN-Abaqus
 - Type of factors -Input parameters- supported by OPEN-Abaqus
 - Type of response -Output parameter- supported by OPEN-Abaqus
2. Methodology: DOE included in OPEN-Abaqus
3. Overview of the Isight Workflow
4. Results from OPEN-Abaqus
 - Database
 - Regression
5. References

3. Perimeter of use for OPEN-Abaqus

Before doing a DOE study, the user has to insure 2 things:

- His model represents the true physical behavior, his model is predictive
- His model is stable, the convergence of his model doesn't depend of the factor value

3.1 Input parameters

OPEN-Abaqus can only manipulate the numerical parameters written into an INP file. These parameters can relate to:

- Load
- Displacement
- Clearance
- Friction coefficient
- Node's coordinate
- Material data
- Element thickness...

3.2 Output parameters

User can select in this preselected list only one response which OPEN-Abaqus will postprocessed:

Type	Name	Option
Element	S	mises, max, mid, min Principal 11, 22, 33, 12, 13, 23
	E	
	LE	
	PE	
	PEEQ	--
Node	U, UR	magnitude, 1, 2, 3
	V, VR	
	A, AR	
	RF, RM	
	NT	11, 12, 13, 14, 15
Contact	COPEN	--
	CPRESS	
Global	FREQ	--

Table 2: Choice of the response

During the design of experiments, OPEN-Abaqus will dress a database with the factor parameters and the response values. Theses values will be written in global axis system and for all sets mentioned by user during the preprocessing

4. Methodology: DOE included in OPEN-Abaqus

Currently, there are two DOE available in OPEN-Abaqus.

- Fractional Factorial Designs with 2 level -FF4- which is already present in Isight,
- Nearly Orthogonal Latin Hypercube -NOLH- which is extracted from an external thesis and directly incorporated into the OPEN-Abaqus workflow by PSA Peugeot Citroën.

The choice of these DOE is due to there perfect complementarities and there efficiency. In fact, the FF4 is used to solve linear problems and the NOLH is better for non-linear problems. Moreover, OPEN-Abaqus allows users to customize there workflow with an external matrix for the DOE.

5. Overview of the Isight Workflow

To develop this tool, Isight was used. In fact, Isight allows developers to chain many actions in an optimization loop or a DOE. Moreover, Isight has to use the PSA Peugeot Citroën own software and hardware architecture.

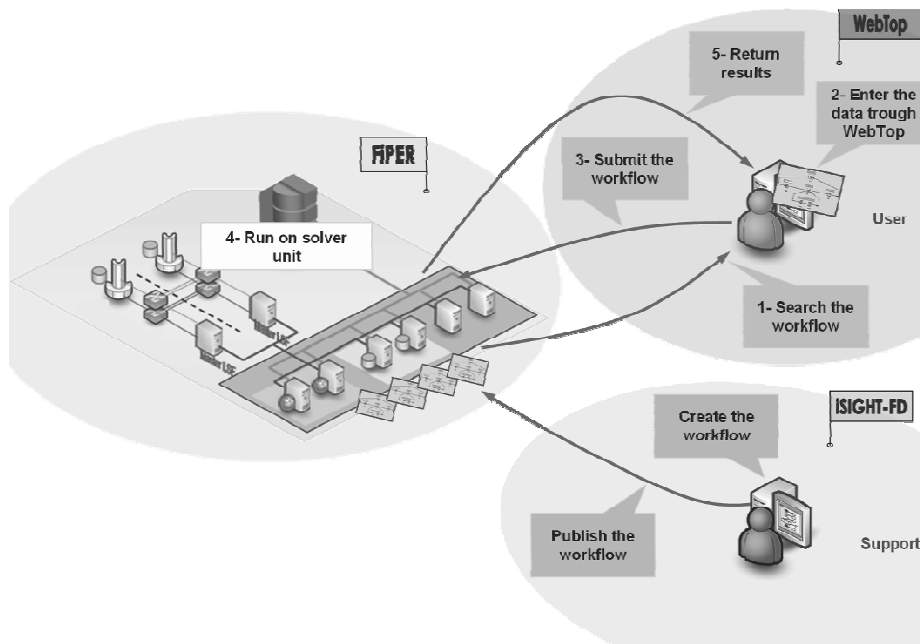
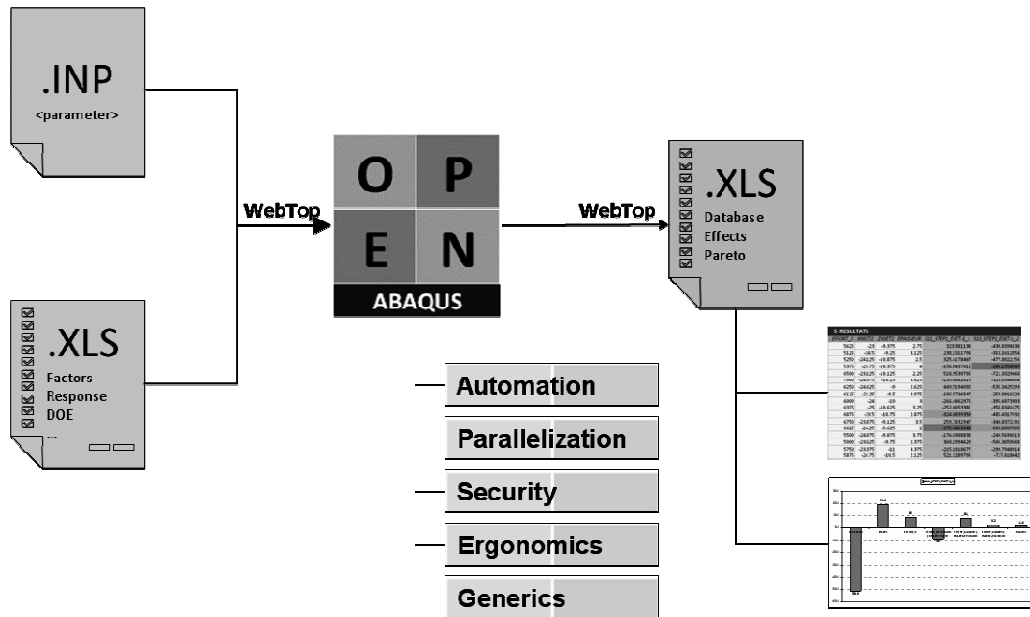


Figure 1: Isight Approach

In the case of Open-Abaqus, user gives to the workflow developed by PSA Peugeot Citroën, the INP file relating to the digital model in which, the value of the numerical parameters is replaced by the name of each parameter. Moreover, he gives an Excel file with all information to run the DOE.



5. RESULTATS				
PRESSION	FLECHEX	DESAXY	DESAXX	Smises/EPOST/STEP1/1
96.25	0.5	0.425	0.25	427.1032104
91.25	0.2	0.45	0.325	378.5067749
92.5	0.275	0.125	0.2	363.8536682
93.75	0.35	0.225	0.5	402.0415649
105	0.475	0.275	0.15	445.4091187
110	0.225	0.25	0.425	451.7806091
102.5	0.175	0.5	0.225	417.5456543
101.25	0.45	0.4	0.475	455.5631104
100	0.3	0.3	0.3	413.7078857
103.75	0.1	0.175	0.35	402.3531189
108.75	0.4	0.15	0.275	449.5443115
107.5	0.325	0.475	0.4	467.8039856
106.25	0.25	0.375	0.1	425.1958923
95	0.125	0.325	0.45	389.3312988
90	0.375	0.35	0.175	377.7436829
97.5	0.425	0.1	0.375	409.5605164
98.75	0.15	0.2	0.125	373.2473145

Figure 3: Database from OPEN-Abaqus

If the DOE is FF4 or NOLH -not the external matrix-, OPEN-Abaqus can do a regression operation which sorts effects and interactions between factors. This regression allows OPEN-Abaqus to draw a Pareto graphic which will be written into the report.

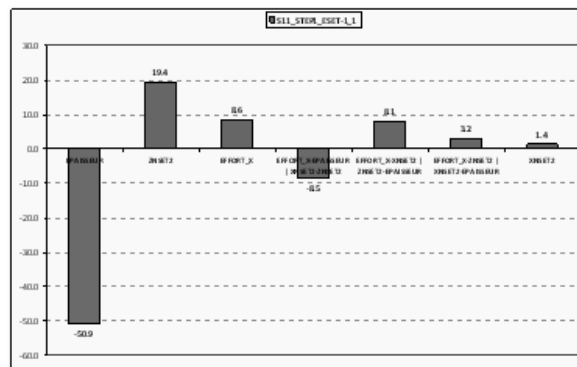


Figure 4: Regression

7. References

- 1.** Faraway Julian J., “Practical Regression and Anova using R”, December 2000.
- 2.** Goupy J. “Modélisation par les plans d’expériences”, Techniques de l’ingénieur no. R275.
- 3.** Lebart L., “Analyse en composantes principales”, Cycle postgrade de statistique, University of Neuchâtel, March - April 2004.