Automated Analysis in CATIA V5

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The traditional process for assessing the strength, stiffness and modal performance of a chassis component such as a suspension link, and iterating the design to meet targets in the optimum way, is time consuming. Some design engineers experimented with using integrated analysis in CATIA V5 to assess and iterate the design more efficiently. Success was limited due to the complexity of setup and poor correlation with the results obtained by CAE specialists using the standardised process.

This paper outlines how a combination of CATIA V5 analysis and scripting was used to solve these problems for a number of component types. The success of the tools released to date and the advantages of using them will be discussed. Guidelines for identifying processes which are suitable for automation will be presented

1. Introduction

The evolution of virtual engineering has led to the design engineer and the analyst being separate, specialist roles. This means that each time an analysis task is required, a CAD model is passed from the designer to the analyst, whose work priorities may mean the task might be delayed in starting. The processing time required is also significant. The impact of the high total time taken to perform one analysis is that the design and analysis iterative loops may be stopped as soon as the component meets the minimum requirements, rather than continuing until it is optimised with all unnecessary mass removed. This is what is meant by the "traditional process" for analysis of a chassis component.

1.1 Problem Summary

The problems experienced through using the "traditional process" for analysis of Chassis components can be summarised as follows:

1. Designs may be completed late
2. Designs may not be fully optimised
3. Analysis expert's time is limited
4. When design engineers tried to use CATIA V5 Analysis, their results might not correlate with those of experts.
5. Standard analysis processes are repetitive: not interesting for experts to complete!

2. Solution

Design engineers experimented with using integrated analysis in CATIA V5 to assess and iterate the design more efficiently. However success was limited due to the complexity of setup and poor correlation with the results obtained by CAE specialists using the standardised process. Analysis experts were able to produce analysis templates that gave results that did correlate to those from their standardised process. Hence a proposal was made to automate the application of these templates to the designer's components, along with the reporting of results, to allow the designers to complete the analysis process themselves. A tool was created to fulfill the proposal using scripting. An overview of the process is shown in figure 1, with more detail given in the rest of this section.

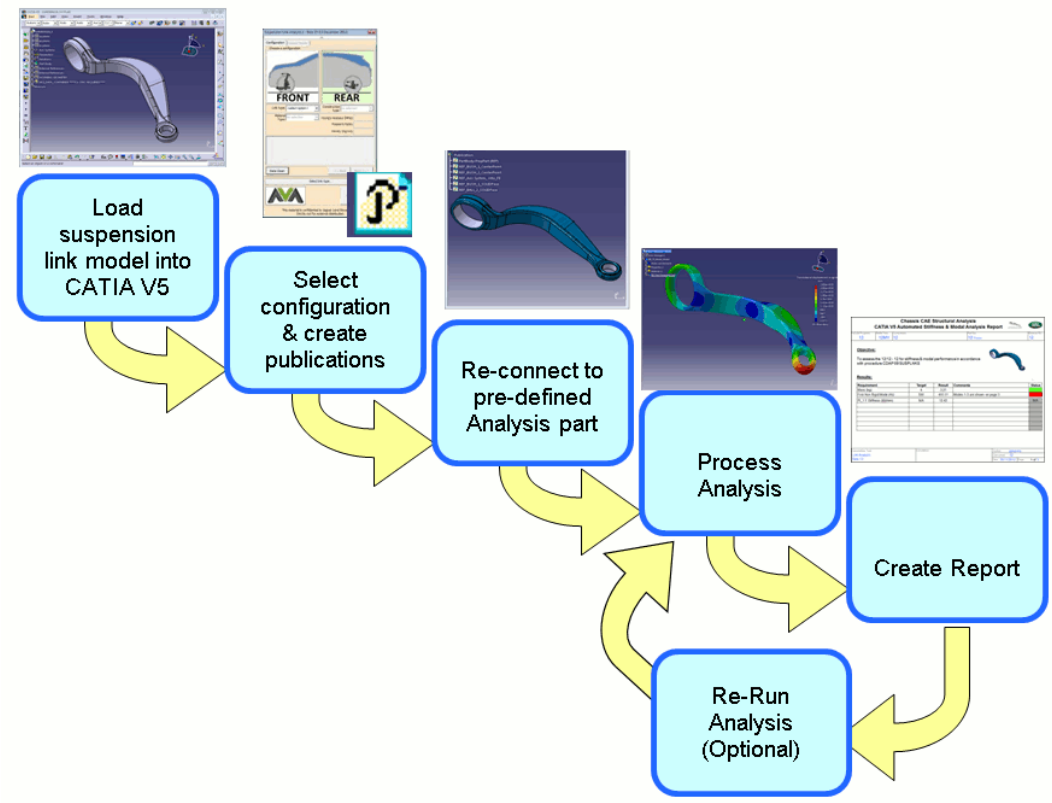

Figure 1. Process Summary Diagram

2.1 Template Selection

A graphical user interface (GUI) was created to guide the workflow. With the component design in-session the designer launches the GUI though a toolbar button. Through making selections on the first page of the GUI the user selects the correct template for their component (see figure 2).

2.2 Geometry Selection

The user makes selections of geometry on their component, to facilitate linking the analysis template to their component. The geometry is then published. If the component is saved with the created publications next time the user does not have to re-select them.

2.3 Link User Component to Analysis Template

The user links their component to the analysis template

2.4 Run Analysis

The user hits the run button and an estimated run time is given. The CATIA V5 session cannot be used while the analysis is in progress. On completion the results are given in a quick results window (see figure 3).

2.5 Create Report

Should the user desire a comprehensive report this can be created (see figure 4). Targets can be input for automatic comparison with the results.

2.6 Re-Analysis

The user has the option to keep the analysis tool open while they change their design. After the changes are made the links between the model and template are updated and the component can be re-analysed without setting up the template again.

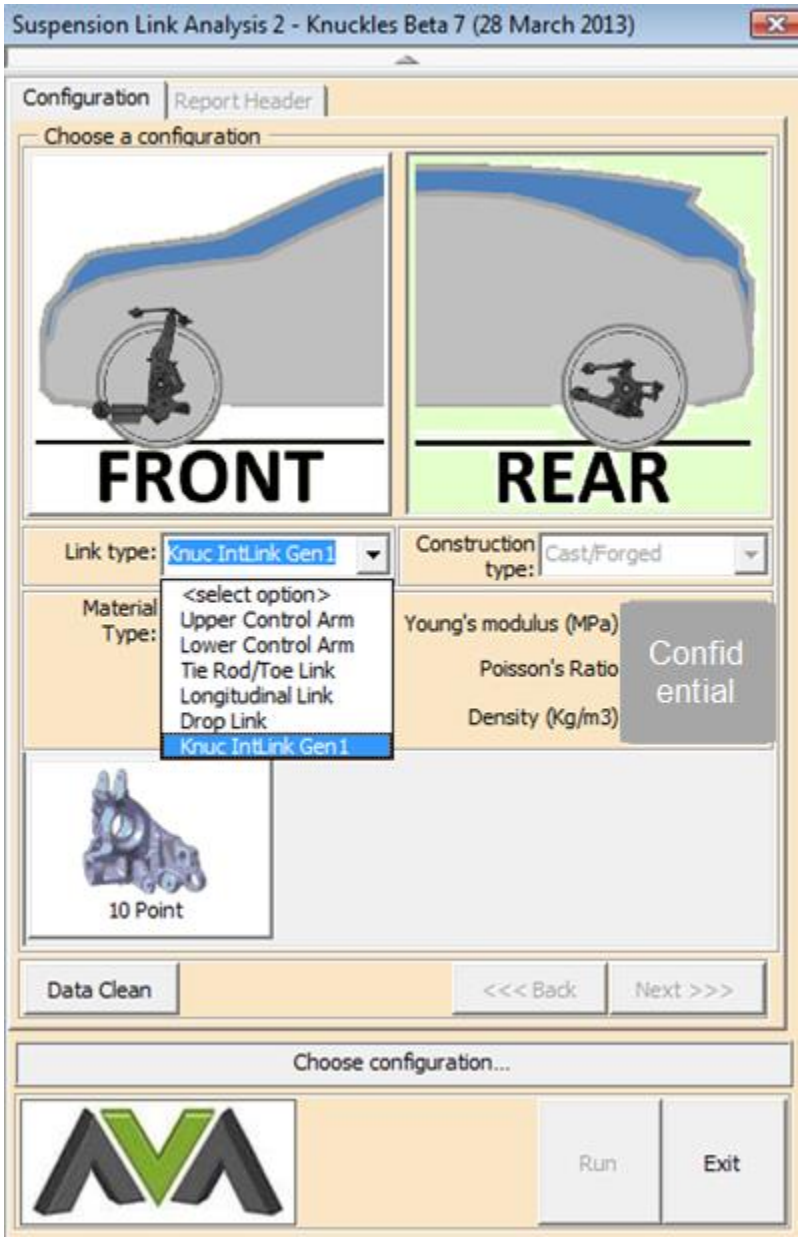

Figure 2. Template Selection in GUI

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Mass: 5.06 kg

Frequency 1: 785.43 Hz
Frequency 2: 919.2 Hz
Frequency 3: 1041.8 Hz

Pt_6 Stiffness (X Part Axis): 7.02 kN/mm
Pt_6 Stiffness (Y Part Axis): 97.52 kN/mm
Pt_6 Stiffness (Z Part Axis): 4.18 kN/mm
Pt_18 Stiffness (X Part Axis): 4.23 kN/mm
Pt_18 Stiffness (Y Part Axis): 77.58 kN/mm
Pt_18 Stiffness (Z Part Axis): 3.03 kN/mm
Pt_59 Stiffness (X Part Axis): 15.49 kN/mm
Pt_59 Stiffness (Y Part Axis): 160.28 kN/mm
Pt_59 Stiffness (Z Part Axis): 13.68 kN/mm
Pt_65 Stiffness (X Part Axis): 8.78 kN/mm
Pt_65 Stiffness (Y Part Axis): 25.45 kN/mm
Pt_65 Stiffness (Z Part Axis): 10.27 kN/mm
Pt_3 Stiffness (X Part Axis): 17.97 kN/mm
Pt_3 Stiffness (Y Part Axis): 19.1 kN/mm
Pt_3 Stiffness (Z Part Axis): 3.08 kN/mm
Pt_4 Stiffness (X Part Axis): 11.43 kN/mm
Pt_4 Stiffness (Y Part Axis): 27.02 kN/mm
Pt_4 Stiffness (Z Part Axis): 1.34 kN/mm
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Figure 3: Quick Results Window

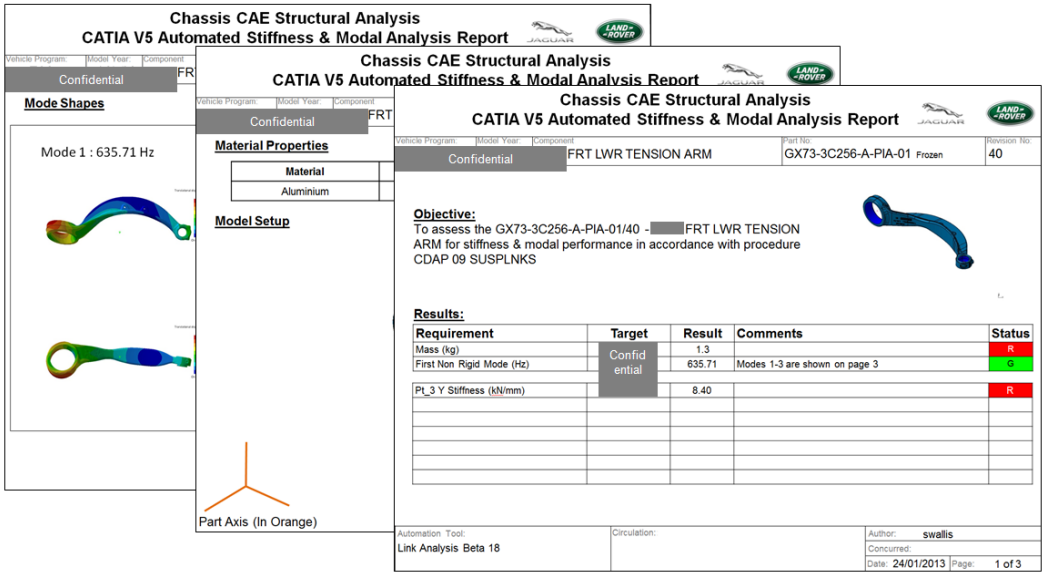

Figure 4. Typical Report

3. Reflecting on the Success of the Tools

To date five automated analysis tools have been created in the CATIA V5 environment, two of those being extensions of previous tools. Good feedback was consistently received from the users, who typically asked for the tool to be extended to contain other analysis processes or onto other components! The benefits of having these tools have far outweighed what was previously envisaged, and has in fact changed the way of working in Jaguar Land Rover Chassis. With the analysis templates linked to the CAD model the efficiency of the analysis-design change loops has been maximised.

3.1 Benefits Summary

1. **Efficiency:** The reduction in processing time for one analysis iteration of comparable level is over 90%. This has supported an approximate 80% reduction in the mechanical design lead time for a front knuckle, when developed by an experienced CAD designer. See Appendices 6.1 and 6.2 for usage and time saving statistics.
2. **Greater Optimisation:** Because of the processing time reduction a greater number of design/analysis iterations can be completed within the same overall time period. Hence in a limited time period a greater level of optimisation might be reached than before.
3. **Repeatability:** Analysis in the design environment will now give the same result regardless of the designer.
4. **Bring Analysis Back In-House:** Because of the efficiency gains it has become possible to refine wheel designs to a greater level in house, reducing the number of analysis iterations done by the supplier. This has saved money and taken 2-3 weeks out the wheel development process.

3.2 Benefits in Terms of the "7 Wastes of Lean"

The 7 wastes are at the root of all unprofitable activity within your organisation.

1. **Defects: Eliminated through repeatability**
2. Overproduction: Not applicable.
3. Transportation: Not applicable
4. **Waiting: Eliminated through analysis on demand**
5. Inventory: Not applicable
6. **Motion: Time spent making analysis requests and moving data is eliminated**
7. **Processing: Processing time significantly reduced**

4. The Future

In the near future Jaguar Land Rover will be migrating to CATIA V6 in the 3D Experience platform. This will open up more possibilities for analysis automation with increased capability, for example non-linear analysis, and further process time reduction, perhaps through batch submission of analysis tasks. We aim to continue to identify processes suitable for automation and create automated tools using a standardised, modular approach which re-uses the experience gained in producing the tools completed to date.

4.1 What Makes a Good Process for Automation?

A summary of the main points to consider when deciding whether a process is suitable for automation is as follows:

1. Is the process standardised?
2. Are the designs to be analysed consistent enough such that they could fit a standardised template?
3. Is the analysis process possible in the CATIA V5 toolset?
4. Is there a business case? I.e. how many times will each template be used?
5. How time consuming is the existing process?
6. How much potential is there to remove mass from the component through manual iteration, which could be enabled through reducing the processing time?
7. Would an automated tool allow analysis to be done in-house rather than outsourced?
8. Is resource available to create the tool?

5. References

1. http://www.isixsigma.com/dictionary/7-wastes-of-lean/

6. Appendix

6.1 Usage Statistics

Tool Details			Usage Statistics		
Tool	**Level of Analysis**	**Number of Templates**	**Release Date**	**Total Usage**	**Usage Per Month**
Engine and Gearbox bracket	Stiffness and strength: not sign off	14	18/08/2014	16	16
Wheel 2	Stiffness: sign off, strength: not sign off	1	17/01/2014	197	25
Suspension link and knuckle 2	Stiffness and modal: sign off	22	25/01/2013	1502	75
Wheel 1	Stiffness: sign off	1	01/11/2011	Not tracked	Not tracked

Note: Usage stats as of 22/9/14

6.2 Time Savings

Tool Details	Before: Approximate Processing Time (hours)	After: Approximate Processing Time (hours)	Processing time reduction for one iteration (%)
Engine and Gearbox bracket	16	0.5	97%
Wheel 2	16	1	94%
Suspension link and knuckle	8	0.5	94%
Wheel 1	12	0.5	96%

Note: Timings quoted are approximate