MODEL CHECKS AND RESULTS EVALUATION FOR STRENGTH AND DURABILITY ANALYSIS THROUGH AUTOMATED REPORTS WITH ANSA & μETA

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ABSTRACT –
CAE significance has gained ground in the recent years through the introduction of the No Prototype car concept. Modern models consist of numerous components with different design variants and CAE needs to face the challenge of minimizing turnaround times and providing error-free processes that will allow engineers to go through simulation results in an effortless and efficient way.

To address these needs, an automated process was built-up by BETA CAE Systems S.A. for HONDA to perform a number of model checks and results queries and present the output in PowerPoint reports. Target components are subframe, BiW and tailgate. Input of parameters is achieved through a spreadsheet file to provide a more user-friendly environment and reduce the chance of error. The procedure, driven by μETA, is executed in batch mode allowing the use of grid computing for the efficient utilization of resources, whereas ANSA is launched internally during execution. A series of actions take place in both software to extract modelling information, load and combine results to evaluate connections and regions of the model and display the above in report slides through images, tables and graphs.

The new approach resulted to a remarkable reduction of time, an augmentation in modelling quality, a more supervisory presentation of the results and a process less prone to human errors. Current functionality is planned to expand within HONDA for the implementation of similar processes for other components.

TECHNICAL PAPER -

1. INTRODUCTION

CAE significance has gained ground in the recent years through the introduction of the No Prototype car concept. Modern models consist of numerous components with different design variants and CAE needs to face the challenge of minimizing turnaround times and providing error-free processes that will allow engineers to go through simulation results in an effortless and efficient way. To address these needs, an automated process was built-up by BETA CAE Systems S.A. for HONDA to perform a number of model checks and results queries and present the output in PowerPoint reports.

This paper explains, in the first part, the goals of HONDA in the field of CAE analysis and product and data management generally. It describes the unified data management both for CAE and test processes and the process control of the data. It presents the role of the CAE automated processes in HONDA, especially the process for the creation of reports.
In the second part, it describes the last reporting procedure developed in the company, the aforementioned procedure provided by BETA CAE Systems S.A. It presents the challenges related to the input of data, evaluation of the results and automation of execution that were faced at its implementation and the solutions followed to meet these challenges. Finally, it lists the benefits derived by the project, the conclusions and the related future plans in HONDA and BETA CAE Systems.

2. PRODUCT DATA MANAGEMENT AND CAE AUTOMATED PROCESSES IN HONDA

Target

HONDA is targeting to build a PDM system that enables managing all types of data related to engineering. HONDA's expectations are that it will be able to create performance-based designs quickly and reduce the time needed for performance verifications.

Data managements and process control

PDM system needs Data unified-management, and specific process controls between databases. Functional database needs to be linked with CAD Data using Requirements Analysis and Performance-based Design Process. In the same way, CAD Database needs to be directly connected with CAE and TEST Data by using specific processes.

Automated processes in strength and durability analysis

This automated CAE System consists of four CAE processes. The 1st and 2nd are automatic modelling and automatic boundary condition definition respectively. Both are based on ANSA. The 3rd process is an Automatic Reporting through Meta Post. The 4th is Automatic Data gathering, which is based on an in-house tool.

3. INITIATIVE – CHALLENGES OF THE PROJECT

Initiative of the Project

In 2010 HONDA made its first attempt to automate the CAE processes for model checking and results evaluation in strength and durability analysis through the software ANSA and μETA. Target component was the side door and the project was outsourced to TOPCAE, the Japanese distributor of BETA CAE Systems. The main characteristic of that project was the achievement in time reduction as the new procedure needed only 20 minutes server execution compared to 12 man hours of manually checking the model set up and post-processing interactively. The success of the project was decisive for HONDA's decision to meet the need for further automation of other components in strength and durability analysis

in a similar manner. Three load cases linked with complicated evaluation procedures were chosen this time –the strength analysis of subframe and body in white with NASTRAN and the tailgate closing simulation with ABAQUS EXPLICIT- keeping as parallel goal the core functionality that will be developed for the aforementioned load cases to be used for subsequent ones as well. The project this time was assigned to BETA CAE Systems, the company developing the software ANSA and μETA.

Challenges of the Project

During the design and realization of the project some challenges arose concerning the input of the data for the process, the evaluation of the results and the achievement of automation. For the data input, common techniques so far include on one hand the manual input applied by the user during a pre-/ and post-processing session. This may include selecting the model files to load, selecting nodes, elements and curves to query values from or adjusting the settings to achieve a display of results that facilitates the extraction of engineering evaluations. On the other hand for the input of data in automated procedures common techniques are the usage of running arguments to pass parameters values when launching an application, input fields in toolbars and scripting interface tools provided by the various pre- and post-processing software and text files with a list of parameters. The challenge in this project was to use a mean to input the data for the automated procedure that will offer a friendly and error-checking interface while being easily expandable, so the solution of XLSX file was qualified. Input was intuitive for the user through colours, explanations and other formatting capabilities and typing mistakes were avoided trough predefined lists to choose from where applicable.

In the field of results and model evaluation, common techniques are first of all the checks for model set up and queries for simulated results performed interactively in corresponding software. Lists of entities, definition checks, field views, curves plots, extraction of problematic entities or regions according to specified criteria are usually among the means used. Automated techniques have as output images, tables and text files, whereas in more advanced cases reports in html and Powerpoint format are delivered but with rather simple format consisting mostly of a combination of images, textboxes and tables. The challenge here was to offer a more advanced format of Powerpoint reports through the use of template files that will offer the desired supervisory presentation of the problematic areas.
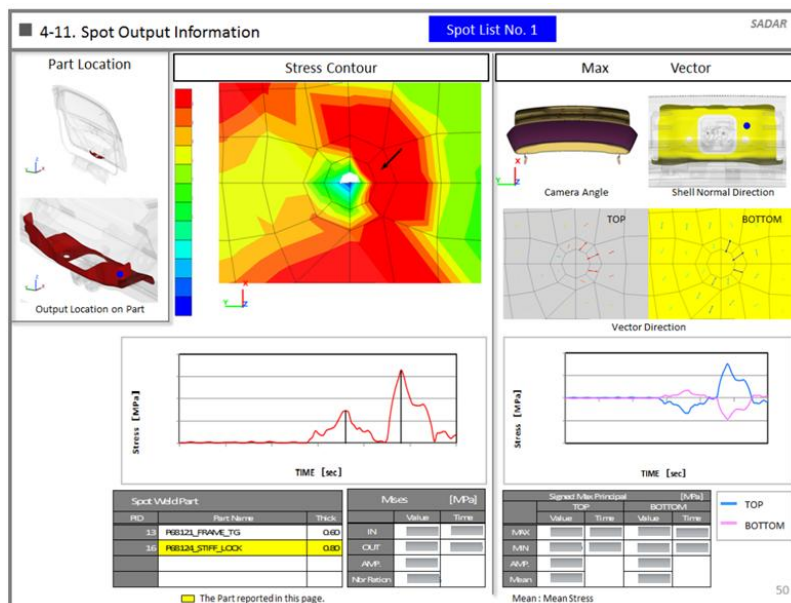

Figure 1 – Slide example for presentation of results on a SPOT

Regarding automation the precedent process in HONDA had been the manual check of the model in a pre-processor and the interactive post-processing. Post-processing included the evaluation not only of one but of a series of results, the isolation and separate treatment of specific areas like the spots, the bolts and the edge surfaces and in certain cases the combination of a number of results on entities. The challenge was to diminish through automation the processing time, eliminate any unnecessary repetitions and avoid the insertion of errors. Errors referred to errors either from the human factor during the execution or from the calculation algorithms. Another major challenge was the replacement of interactive evaluation and results visualization by smart algorithms that would lead to the same outcome.

4. DESCRIPTION OF THE PROJECT

General

The project was initiated in the beginning of 2012. Its target was the creation of an automatic process for the extraction of reports with model and results information for three components, the subframe and the body in white, analysed with NASTRAN static analysis (SOL 101), and the tailgate analysed with ABAQUS EXPLICIT. Basic principles of the project were the use of one common input file for all three components, the goal for no manual interaction throughout the whole process and the ability for batch mode execution. The development of the necessary scripts and of some new functionality in ANSA and μETA from BETA CAE Systems was realized during a period of five months. The deliveries consisted of three μETA session files, one for each component, which ran internally a number of script files and produced the nine different reports requested by HONDA. The XLSX file for the input of data included approximately 400 parameters, some common for all parts and some specialized for one of them. The reports created varied in number of slides as this would depend on the parameters given, with typical reports consisting of 15 to 150 slides.

To meet the aforementioned challenges a series of tools of the two software, ANSA and μETA, were used. The utilization of an XLSX file was made possible through the spreadsheet editor tool, whereas the need for a supervisory presentation of results in the report was met by the report composer tool and its support of importing existing reports as template files. To be able to replace the results evaluation and presentation procedures done manually through automated advanced algorithms, it was necessary to resort to the capabilities of the scripting language, make use of the options in advanced filter tool and to take advantage of some embedded annotations functionality to distribute annotations successfully on the screen and produce efficient images. The scripting language contributed additionally to the significant reduction of processing time, especially since it was achieved to avoid the manual reading of the input files (by extracting all information from ANSA and μETA) and to eliminate any repetitions of results and procedures. The final achievement in time reduction was impressive: for subframe 2 days of manual interactive process were replaced by 3 minutes of server execution, for body in white 4 man-days were replaced by 10 minutes of server execution and for tailgate 5 man-days were replaced by 30 minutes server execution time. The necessity for an error-proof process was handled by building a process free of manual interaction, driven entirely from scripts in a robust and repetitive way. To assure the correctness of the process, internal verification mechanisms were developed, which made the process mechanisms transparent and could offer visual inspection of the final results.

The processes together with the input data files and the possible output combinations are shown below. All possible outputs are reports in PPTX format. Depending on the user request it is possible to create one report with only information about the model set up, one with only information about the simulation results, one with both information in one combined report or two separate reports. Depending on the type of the requested report(s) the appropriate model and results data files in NASTRAN and ABAQUS-EXPLICIT format are loaded and the corresponding process is executed in batch mode calling ANSA and μETA.

Model information refers to all subcases, whereas results information refers to one of the subcases, explicitly defined as parameter of the execution.
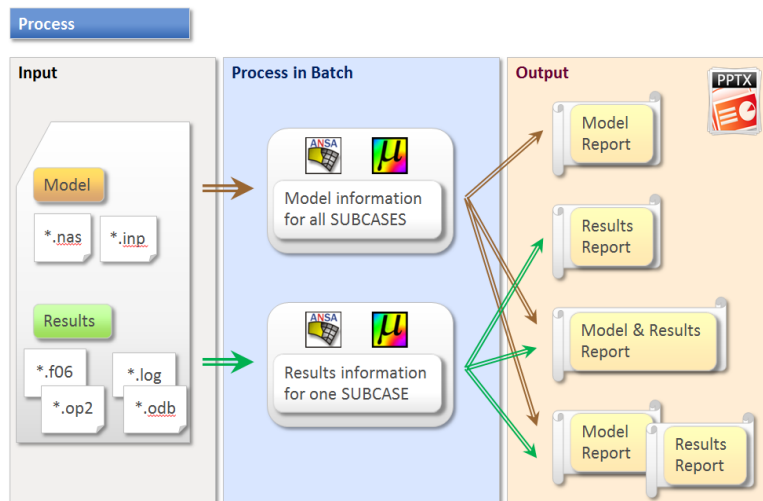

Figure 2 – Input data, process and output data

Analysing the batch process in more detail, the whole procedure is steered by a μETA session file. In the first part the installation parameters are defined as simple μETA variables. The installation parameters include data that need to be defined once for each installation of the process, like the location of the script files, the report templates and the views files. The second part includes the extraction of model and results data. The parameters referring to each individual evaluation are loaded, like the values from control file or the data from the view files. Then, according to these values ANSA is called internally to export model data to CSV files and μETA to load results, perform calculations and extract model and results data to images and CSV files. The third part of the process is related to the report creation. Inside μETA the correct template for the procedure is loaded from the templates library and the report is created by updating text, images, tables and graphs in the slides with the new generated data, creating a series of new slides where necessary using an existing one as template and deleting unnecessary slides. All output data files are deleted or stored according to user requirements. At the end, a log file is exported as well – a simple text file with the execution information about the process and some summary information of the evaluation.

Regarding the file management, all intermediate images and text files are temporarily stored first in an output directory which is defined among the execution parameters. Then, the files are inserted in the report templates to build the final reports and afterwards, the files are either deleted or placed in a location specified by the user, the object files directory, under separate folders per content.

Throughout the process, information appears in the terminal to keep the analyst posted with the current status of the execution. In case of data inconsistency, warnings or error messages are displayed depending on the severity of the problem. Information is cited about the data files, from which geometry and results are loaded, the report template imported, the final report generated. As a result the user has a complete and detailed image of the process mechanism and can easily verify the validity of the data utilized.

Areas of Interest

In the project the model is divided in distinct areas, referred to as areas of interest from now on in this paper, and each area is investigated separately. These areas are the spots and the elements connected to them according to strict geometrical specifications, the bolts and similarly the elements connected to them, the connectors, the mig connections either taking

into account the whole area along the mig connection or only the two edges of the connection, the edge of the shell surface and the rest of the shell elements area. Especially for the edge shell surface and general shell surface areas, these need to be extracted in the end after all previous areas of interest have been defined so that the latter are excluded from them.
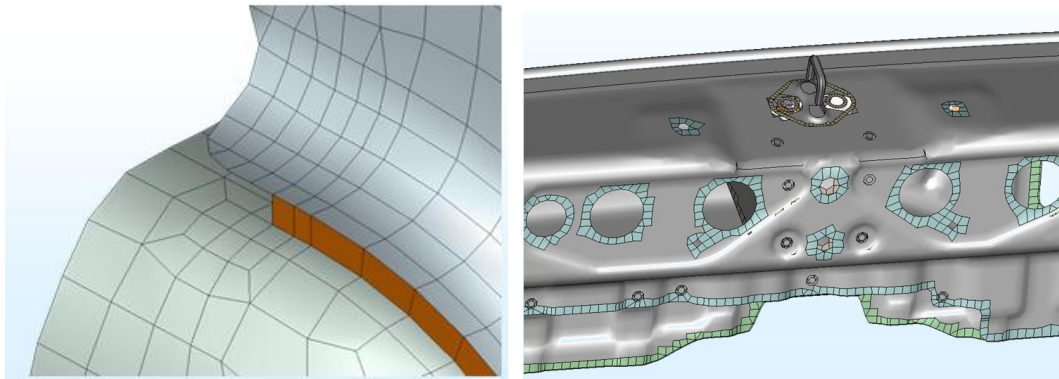

Figure 3 – Migs and edge shell surface, two of the areas to be treated separately

Different areas of interest are applicable for each component. The specifications for the post treatment of each area of interest are strict and involve the definition of the elements belonging to each unit of the area (one spot face for the spots area of interest, one mig edge for mig edges area of interest, etc) through geometrical criteria, the extraction of the failed elements according to specific threshold value and their further individual post-procedure related to each component needs.

Model Check

One of the two major functions of the process is the check of the model set-up for the simulation analysis. General information about the model is presented like the total number of the various elements types (sets and other entities), the parts and materials information while their location is displayed on the model, the centre of gravity and moments of inertia data and the information about the subcases. This way, it is assured that the model has been solved with the correct data. Boundary conditions are displayed so that it can be visually inspected in a fast and effortless way that the correct load has been applied on the appropriate position or that the correct nodes have been constrained.
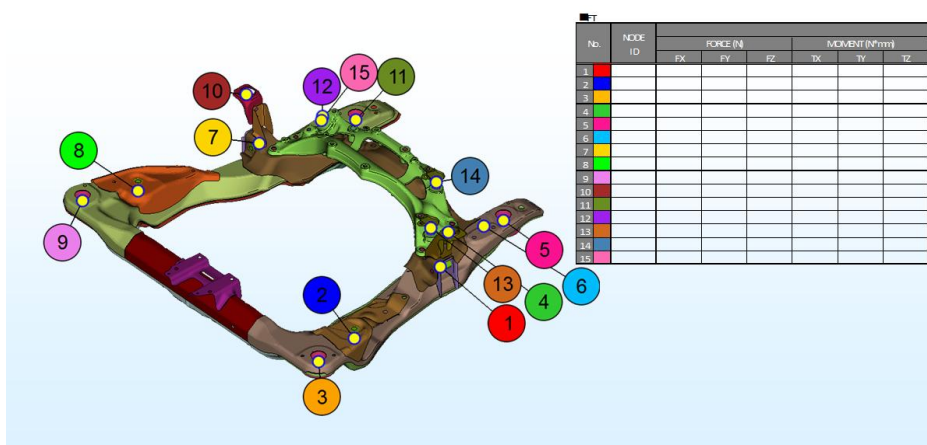

Figure 4 – Boundary conditions

An overview presentation of the model is created to check the total numbers, total length and positions of each connection per type or per connectivity. Further model checks include the display of the masses or the springs present in a model and their properties.

Results Query

The second major function of the process is the query on results in order to recognise problematic areas and entities. The user in this case has a very powerful and in detail control of the manipulation of the queries and the definition of failure. Searching for failure can be performed using separate results variables, so that spot elements are evaluated on axial force, elements on spot faces are evaluated on Von Mises Bending stress at their top face, bolt elements on shear plane1 and elements on bolt faces on Von Mises Membrane stress at their bottom face. Different limits are defined for each area of interest, while different limits can be used optionally for some materials of the model. To obtain a better view of the area where failure occurs, ratios of the failed elements and the surrounding elements are calculated and displayed. All above are streamlined from the simple and explanatory interface of the XLSX control file.

Furthermore, in certain cases, interdependency among two or more results or between a result and model data is demonstrated in calculations, as in the slide below, where absolute torque values of spots are assigned to the connected parts and grouped according to the thickness.
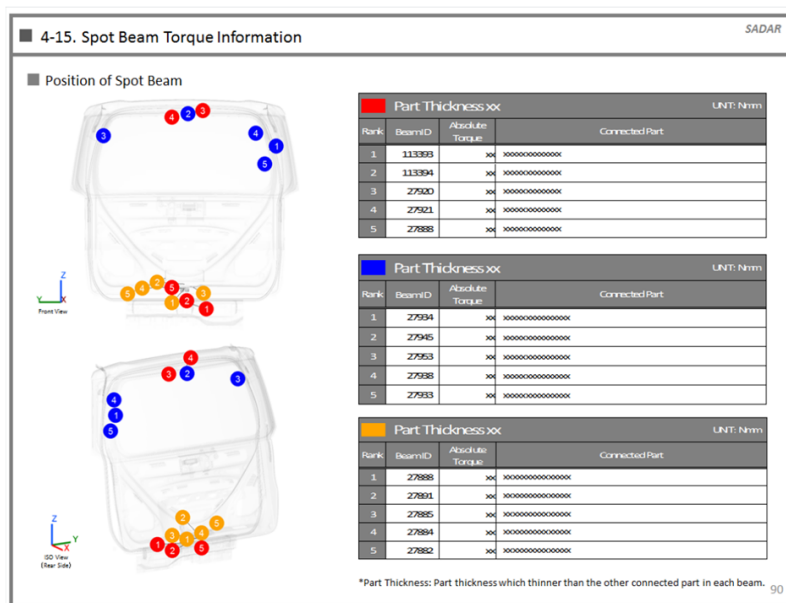

Figure 5 – Slide Spot torque, example of interdependency between results and model data

Especially for the areas of interest, the results query consists of a number of special, individual rules to be followed at each area. For spots, bolts and migs each connected part is handled separately. Advanced algorithms are used to collect the connected shell elements according to very specific HONDA specifications, to search in case of migs either the whole mig or just the edges of it and, in addition, to identify the root and end side. For the edge shell surface and general shell surface areas, regions of the surface are identified first, so that only the maximum position in each area is kept and evaluated subsequently for failure. The threshold value for the identification of the regions again is explicitly stated by the user in the control file and could be different for edge and general surface.
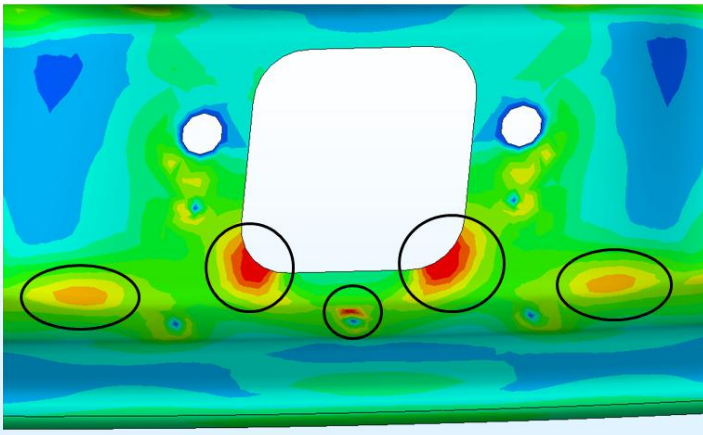
Figure 6 – Regions identification for edge / general surface

Images of the locations of the failed spot/bolt/etc. offer an efficient overview over the results, while one slide per problematic entity is created providing a supervisory display of multiple results on the area.
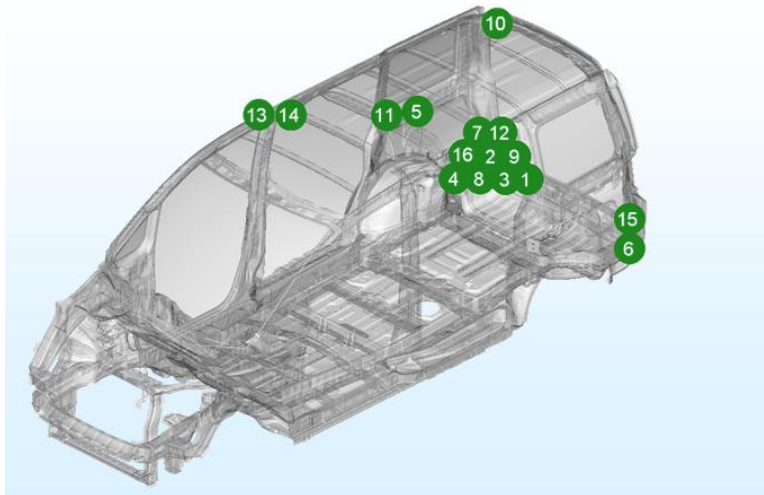

Figure 7 – Overview image for failed bolts

Local Areas

Apart from the overall evaluation of the model there exists the need to investigate a number of crucial areas of the model in more detail, referred to as local areas in this paper. Since the local areas can be altered in future variants of the component or the number of the total areas to be investigated may vary, the process should offer the necessary level of flexibility, and therefore all related data have been parameterised. There can be a variable number of local areas, while each area is characterized by a centre position, a radius around it forming a sphere and the parts to be considered, all above defining the model area to be processed. In this model area all spots, bolts and other areas of interest are found and displayed regardless of their failure status. For the extraction of images all local areas are accompanied by saved views to be used, which are additionally adjusted for each new variant so that the area is positioned correctly according to the new defined centre location on the model.

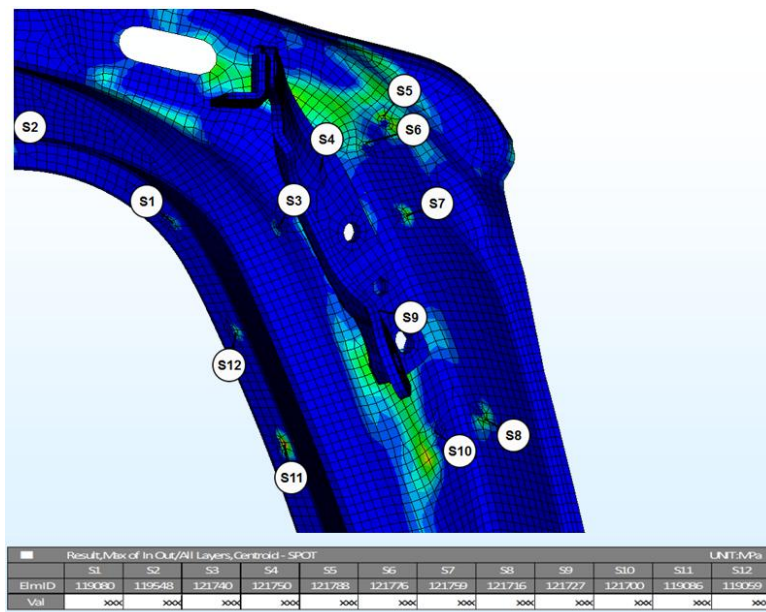| Result,Max of In Out/All Layers,Centroid - SPOT											UNIT:MPa
S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
119080	119548	121740	121750	121788	121776	121759	121716	121727	121700	119086	119059
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

Figure 8 – Spots in a local area

In order to orient the analyst about the local areas and the corresponding views, representative images are created automatically locating the local areas centre positions and search areas on the model and displaying the views directions.
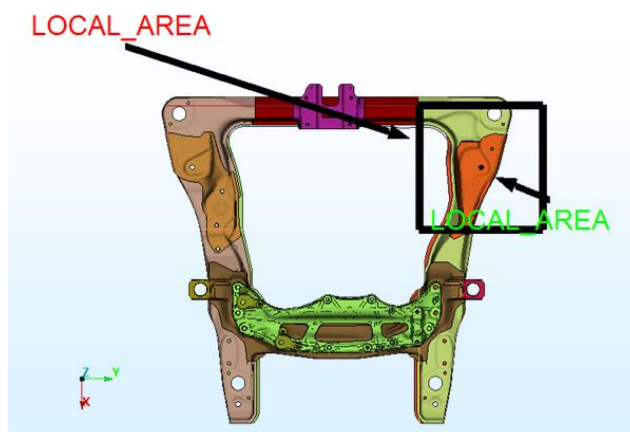

Figure 9 – Image for local area location and views direction

Verification Mechanisms

The assurance of the results quality was a crucial aspect of the project as the latter involved the evaluation of results, so an error in process calculations would have a serious impact on the concluded evaluations of the components. To meet the above need certain verification mechanisms were developed with the purpose of facilitating the inspection of the calculations outcome. Visual inspection of the results is offered where possible – states are created for every new calculated result so that they can be displayed as contour, the elements or nodes derived from the specifications filters are put to sets. So, the analyst can have a direct access to the spot elements and the elements connected to each spot according to the HONDA specifications, or to the spots, bolts and other areas of interest that were found to belong to a local area.
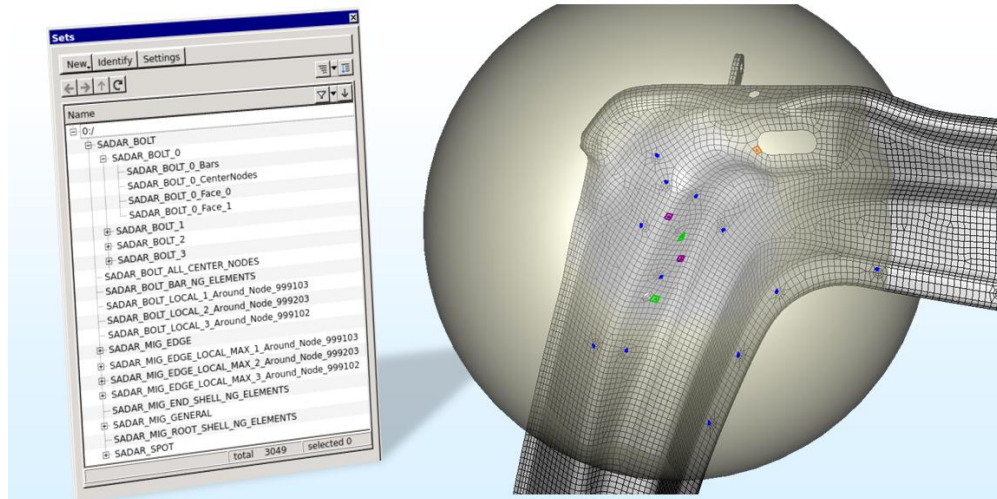
Figure 10 – Sets created by the process in the sets list of μETA and spots, bolts, edge surface and general surface elements of a local area coloured accordingly

In order to assure validity of complex queries these queries are performed in the Advanced Filter tool of μETA. The tool is a well-established tool of μETA offering thus the necessary robustness and an interface for intuitive formulation of complex filters. The tool provides, moreover, the ability for the filters to be readily applied interactively as well, in order to check the outcome in more detail. Furthermore, the calculations for the identification of failure in the various areas of interest, spots, bolts, etc., are performed by the same group of functionalities, which is also common to all components and to NASTRAN and ABAQUS.

Complementary to the above, an additional verification mechanism was developed for the project, the option to run the processes in debug mode. The mode is activated by a simple switch in the delivered project files. In this mode a log file is created automatically bearing extensive information about the process advancement and calculations, all in an easy to read and follow format. Throughout the displayed information there is a direct reference to the project files functionality so that it is easy to apprehend the calculations and capture the path followed by the procedure. More results and sets are kept or derived during the process, so that the analyst can have a full list of the outcome of each calculation, for example one set for each spot and for each face connected to the spot.

5. CONCLUSIONS

Conclusions

An automated process was built-up in HONDA to perform a number of model checks and results queries and present the output in PowerPoint reports through the use of ANSA and μETA. The reduction in time and use of resources was impressive as 16, 32 and 40 man-hours of manual operations were replaced by 3, 10 and 30 minutes server execution for components subframe, body in white and tailgate respectively. Taking advantage of the grid execution system of HONDA led to even better utilization of resources.

The input of data in the process became user-friendly through the interface of a spreadsheet file and making use of the supplementary attributes offered in such a file. Eliminating manual interaction but substituting at the same time all actions necessary for the model evaluation successfully resulted to an error-proof procedure, easier to adapt by new users without the need of key-users. Finally, the supervisory presentation of results on each problematic area, in combination with the display of checks related to model setup, has contributed to an augmented modeling quality.

Future Plans

HONDA's major goal for the future is the automation of the procedures regarding all components in strength and durability analysis. The project described in the current paper involved three of the most complicated and extensive evaluation processes with ultimate purpose to use them as guides for the rest. The core calculations were designed in such a way as to allow their usage as library functionality in future processes development. Another major goal of HONDA is to combine the reporting capabilities of μETA with Open Data Service (SDM/ASAM MDM) and create similar processes for stress measurements and durability tests data.

On the other side, BETA CAE Systems S.A. investigates the possibility of the design of a widely used scripting interface inside ANSA and μETA using the new Python scripting capabilities of the two software that will provide the necessary means in order to allow the effortless built-up of automated procedures to present model and results information.

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