AUTOMATED REPORT GENERATION OF CORROSION PROTECTION SIMULATIONS.

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ABSTRACT –
Numerical simulations continue to gain importance in reducing the development time in the automotive industry. Early stage product development is crucial to allow the integration of novel vehicle models in existing production facilities and current vehicle models in new production facilities. Therefore, the BMW Group focuses on simulations regarding paint shop processes. Specifically to ensure basic corrosion protection of all vehicles, simulations are carried out for dipping, electric deposition of E-coat, and curing of process materials in all paint shop ovens. It is challenging to efficiently display complex simulation results in an easily comprehensible manner. The current standard is to manually generate reports, which generally takes up multiple hours.

To combat this time consuming process, a solution approach was set up with the goal to be able to create reports without the need of any intermediate human interaction. The presented solution approach implements automated report generation including the connection to a database for retrieval of part names based on unique part numbers. Moreover, grouping of vehicle modules analogue to a company-wide standard, applying advanced filtering techniques to find, for example, local minimum and maximum values of E-coat layer thickness, and excluding insignificant simulation results will provide a concise report. An effective way of conveying simulation results can be achieved by realising links throughout the report for easy navigation, displaying contour plots in various standardised orientations, and providing detailed information about individual regions of interest. Modification of the generated reports should be straightforward and shall not require programming knowledge, for example by utilising a customizable template. The time saved by automatic report generation is a contribution to increased efficiency for product design. The time saved by automatic report generation can be invested more effectively in the development of simulation techniques, iterations within product design, and allows for an overall larger involvement in different projects.

TECHNICAL PAPER –

1. INTRODUCTION

Manufacturers in the automotive industry must continue to become more efficient in terms of reducing development time to remain a competitive edge. Utilising and relying more on numerical simulations is one method to do so. A high number of virtual product iterations are possible and the total effort in destructive testing is aimed to be reduced. Additional to reducing development time, early stage product development is necessary to ensure a desired flexibility. The integration of novel vehicle models in existing production facilities and current vehicle models in new production facilities can be virtually investigated by means of numerical simulations.

The manufacturing of vehicle models comprises four main processes. Generally, parts are formed in the press shop and joined to represent the body-in-white in the body shop. The body-in-white passes through the paint shop and is provided with its corrosion protection materials and final appearance. Lastly, the vehicle is completed in final assembly. The present work focuses on the post-processing of numerical simulations that are carried out regarding the paint shop.

2. PROBLEM DESCRIPTION

Basic corrosion protection is ensured for all vehicle models through the process of electric deposition of E-coat. This process requires the body-in-white to pass through multiple basins of pre-treatment materials, amongst other consecutive basins. Passing through these basins is referred to as dipping and this is simulated to virtually inspect if the pre-treatment material reaches the required areas of the car as well as if enough excess pre-treatment material is drained from the body-in-white before dipping into a consecutive basin. To ensure the required E-coat layer thickness, the deposition rate is simulated as well in an early stage of the product development.

After passing through the basins to facilitate the electric deposition of E-coat, the body-in-white is conveyed through an oven to cure the E-coat. The curing of the E-coat material is also simulated by investigating the temperature distribution over time that the body-in-white experiences inside the oven. Furthermore, joints that are realised with structural adhesives are checked for curing as well and adhesive failure of these joints due to temperature differences or differences in thermal expansion for a hybrid material concept is addressed.

All simulations are derived from CAD data of the various product design phases. The simulations carried out for the paint shop are converted from crash models through multiple pre-processing steps to save resources by preventing the preparation of similar models from scratch. Once the model has been prepared, the simulation can be run and the results can be post-processed afterwards. This process is outlined in Figure 1.

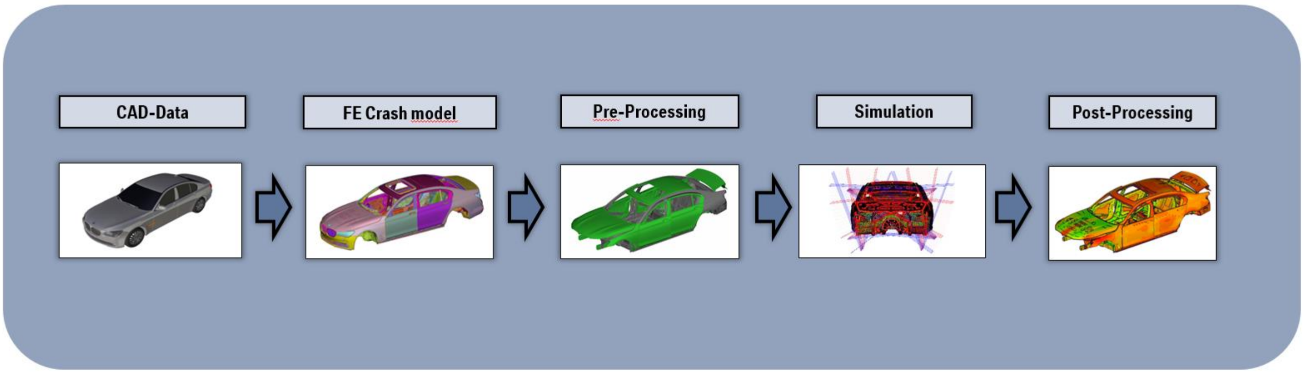

Figure 1 – Steps taken in the simulation process with respect to the paint shop.

The results of the mentioned numerical simulations are communicated internally by means of reports. It is challenging to efficiently display complex simulation results in a manner that is easily comprehensible. Currently, reports are generated manually and this may take up multiple hours of post-processing.

3. SOLUTION APPROACH

To reduce the time consumption that goes into manually generating the simulation reports, a solution approach was set up with the goal to create reports without the need of any intermediate human interaction. The automatic report generation implements different strategies to cluster simulation results and label modules and parts of the body-in-white accordingly.

Throughout the company, every structural part is provided with a unique number that is connected to a part name. Although the part name will remain equal across different design phases, the part number may change to indicate design iterations. The automatic report generation shall be designed to connect to a database that links the part number to the part name. By utilising this information, a clear overview can be provided in the report about which part is currently displayed. Furthermore, this will allow the report to be clustered according to structural module (front, underbody, etc.) and can be provided with links to improve ease of navigation through the report.

The goal of the presentation of the simulation results is to clearly convey areas of interest that might require attention in terms of design alterations. Hence, various standard views are included for every part. The application of filtering techniques is intended to show local minimum and maximum values of, for example, E-coat layer thickness. The advanced filtering techniques can also be used to exclude any insignificant simulation results to make sure that a concise report will be generated. Examples of how the simulation results can be displayed are shown in Figure 2. Results of the thermal simulations are shown on the left hand side. The right hand side of Figure 2 shows how the results of the thermomechanical simulation, assessing adhesive failure, can be displayed.

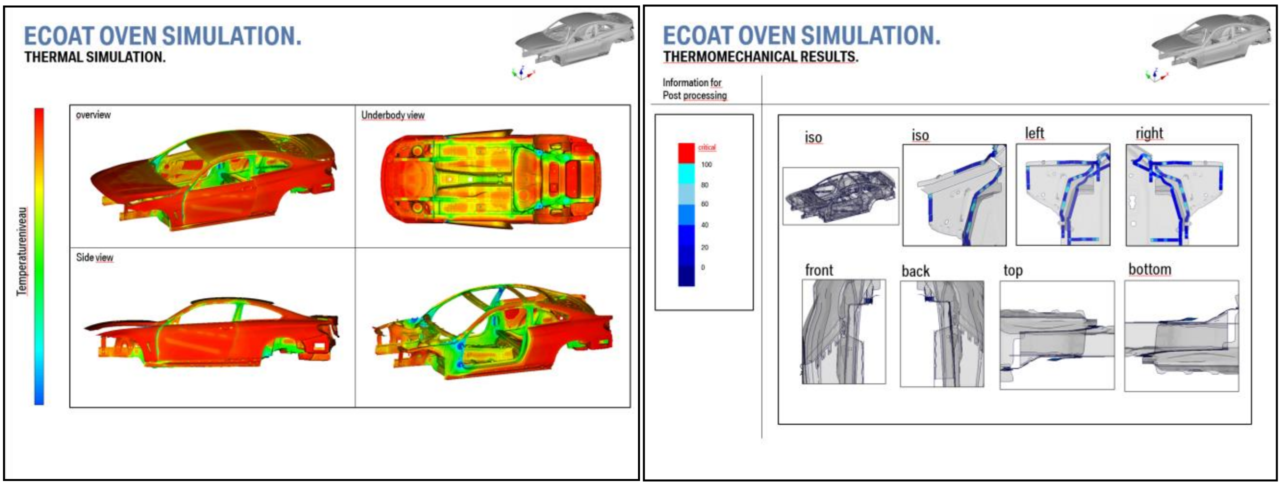

Figure 2 – Exemplary presentation of thermal and thermomechanical simulation results.

Easy customisation of the automatic report generation could be achieved if the report generation is based on a template. If this is implemented, adjusting the layout and style of the report can be done without any programming knowledge. It also provides the possibility to quickly generate different styles of report to see which style fits best for different departments. A general idea of how such a template and the corresponding report would look like is shown in Figure 3.

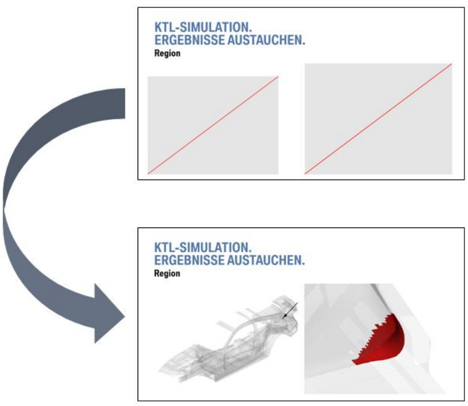

Figure 3 – Automatic report generation based on an easily customizable template.

Finally, the automatic report generation method could also be used to quickly generate general information about a vehicle model. An example of this would be to provide information on the total weight and surface area of specific structural materials of the body-in-white. A use case for this would be to automatically generate a catalogue that is used for the electric E-coat deposition process. This catalogue is used as an indication of how much E-coat material is required per body-in-white, based on the distribution of coated surfaces, see Figure 4.

Material:	Fläche:	KTL-Fläche:	Anteil: (beschichtbare Fläche)
Stahl	xx m^2	xx m^2	xx %
Al – unbeschichtet	xx m^2	xx m^2	xx %
Al- beschichtet	xx m^2	xx m^2	xx %
CFK	xx m^2	xx m^2	xx %
Restliche Kunststoffe	xx m^2	xx m^2	xx %
Gesamt	xx m^2	xx m^2	xx %

Figure 4 – Generation of auxiliary documents based on prepared simulation models.

4. CONCLUSION

The presented solution approach attempts to combat the time consuming process of manually generating reports through post-processing. Clear and concise reports can be generated by adopting advanced filtering techniques to indicate areas of interest and to remove insignificant simulation results. The generated report will be easy to navigate as the results can be clustered according to structural modules. Straightforward adjustment of the generated reports is feasible as the report is generated according to an easily customizable template. The saved time can be more effectively invested in the development of simulation techniques and iterations in product design as opposed to manually generating reports.