Abstract for a paper to be presented at the „3. LS-Dyna Forum" Bamberg/ Germany

Title: Creating Processes for CAE Automation

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1. Abstract/Background

The speed of the development cycle in structural CAE is strongly dependent on the discritisation (meshing) of the FE models. Whereas 15 years ago, it took the Automotive Industry 3 month to build a BIW model , this time is now down to 3-5 weeks. This speed up is due to better CAD surface data and more powerful CAE preprocessors. But still this time is too long because decisions in the design development process are made on a daily or weekly basis. This timescale is too short for complete or even partial model updates. Therefore there is a necessity to further speed up the modeling process to enable decision making, based on CAE performance predictions and to make the modeling process cheaper.

2. Process boundaries for Automated Meshing

At the beginning of the FE process there is the complicated process of producing the finite element model. Whereas in the past most of the work was done by hand, the pre-processors together with the improved CAD data quality make it possible to produce FE models in an automated or at least semi-automated manner. Prerequisites for an process automation are:

- Reduced element size (down to 3 mm)
- CAD data specially prepared for the meshing purpose
- Model assembly has to be automated (model welding, preserving model hierarchy, materials, properties, …)

The main constraints in further modeling speed up for structural FE analysis in Automotive industry is the CAD quality for the purpose of composing FE meshes and the element size of the Finite Elements itself.

2.1 CAD Data Quality

For the purpose of FE meshes, the typical CAD data found in the databases of the Automobile OEM, is usually detailed and full of errors (e.g. unstiched surfaces, holes, …). State-of-the-art preprocessors have good capabilities in CAD enhancements but the enhancement process itself is iterative and time consuming, when carried out manually. To speed up the CAD enhancement process, to gain reasonable CAD data for the FE Meshing, the enhancement process has to be automated or at least to be semi automatic The CAE Engineer is able to judge the CAD data quality for meshing and is guided through the enhancement process.

2.1 FE element size

The size of a state-of-the-art BIW FE Model for structural FE calculations is about 1 million elements. The main constraint for not going further in the details of the geometry is restricted Hardware level. Bigger models require more memory for the pre- and post processing and more CPU power (memory) for the calculation. The gain from more detailed, at the same time meaning bigger, is the better accuracy of results and a easier meshing process as documented in the following images.

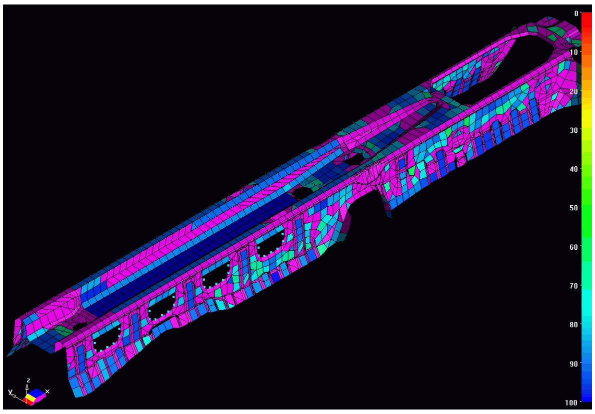

Fig 1. Mesh Quality for coarse mesh

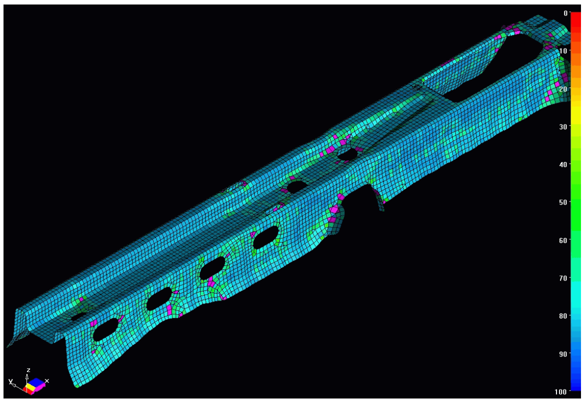

Fig 2. Mesh Quality for fine mesh

Considering that a reduction of the element size of 50% gives 4 times bigger models, an automated meshing process as it is described will end with model sizes between 2-5 million finite elements. This brings to the fore, the major constraints of current hardware. Higher CPU demand for calculating for elements, and higher CPU demand for smaller time steps (especially for explicit codes). Therefore supercomputers from the format of vector machines or Linux clusters have to be used to overcome these obstacles, for especially the commercial crash codes run fast on these machines.

2.2 The automated meshing process

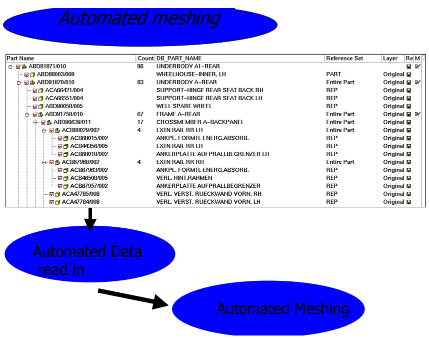

Fig 3 Automated Meshing Process

The process, which was developed, consists of the following workflow:

2.3CAD data enhancement

To gain CAD Data suitable for FE meshing, procedures was developed to guide CAE engineer, with the help of a toolbox, through this process. Time should be not more then 10- 15 Minutes per part.

2.4Batch meshing process

Once the CAD data has the right level of quality, the actual meshing will be done fully automatically. A program therefore has been developed to make the following procedures possible:

2.4.1 Automated data read in

The CAD data is read in the pre-processor. The original CAD file hierarchy is used.

2.4.2 Automated meshing

Once the CAD data is read in, the meshing is done automatically, by the TEC ODM pre-processor using existing auto meshing features. The mesh part is written out into a database

2.5 FE model Quality check

The batch meshing process can be done overnight on suitable computer hardware (PC Type is sufficient). The product is a jointed FE BIW model. To give the customers satisfaction in terms of quality, the whole model must be checked. Therefore tools were developed to guide the CAE engineer quickly to this process. Overall time is less than 5 minutes per part.

2.6 Technical background

Alpha Version of TEC ODM

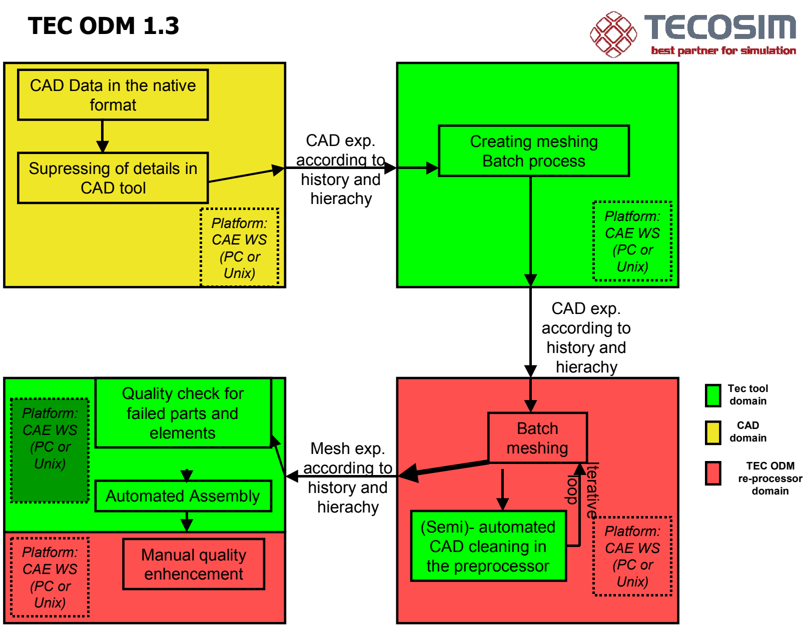

Fig: 5: TEC ODM Process

2.6.1 CAD treatment in the CAD or Preprocessor domain.

In the CAD native tool (UG, Catia, ideas,…) or with the aid of the TEC ODM CAE pre-processor features the surfaces must be prepared as much as possible for the FE dicretisation. This can be achieved by suppressing certain details, creation of midsurfaces etc. This work has to be done by the CAD designers, who know best “their” parts and the history of the design. Out of the CAD tool comes a complete midsurface description of all BIW CAD parts. The details are highly suppressed.

2.6.2 Mesh quality enhancement and automated assembly

The mesh out of the mesh algorithm still has some errors. These errors come from the discretisation of the previous stage where some areas cannot be solved for defined mesh sizes. An iterative process will start to automatically remesh these areas of interest. The algorithms that will be used for this process are experienced based. To improve mesh quality software is developed which uses some extensive computer power. Quality target for the mesh enhancement Software is a more than 99.999% error free mesh, which satisfies all required mesh criteria's. Pentrations are treated automatically to a high degree.

2.7 Realised product

2.7.1 TEC ODM process software

TEC ODM was developed to reduce the time needed for the meshing job drastically. On the one hand it creates bigger FE models which require further investment in Hardware for their solution, on the other hand the process itself can be run on small machines. The process itself is ready to use.

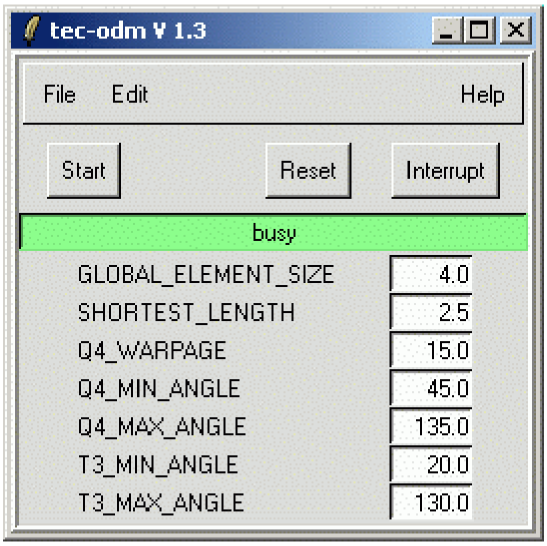

Fig. 6: TEC ODM GUI

2.7.2 TEC ODM process software performance

▪*Benchmark results for TEC ODM*
Number Crunching for TEC ODM on different OS and platforms on a test files (one Part) for 1 processor
§Athlon XP 2400+ 2.0GHz Os Windows Run Time: 5000 sec.
Athlon XP 1900+ 1.6GHz Os Linux Run Time: 2500 sec.

Itanium 2 64bit 1.6GHz Os UNIX Run Time: 3100 sec
NEC SX6I UNIX Run Time: 22700 sec
Benchmark results for the model build with TEC ODM

Number Crunching of the 5 mio. Element model with LS Dyna

Itanium 2 64bit 1.6GHz; 8Gb memory, Run Time: 1530h (~64 days)
16 Proc.; AMD 1900+ 32 bit; 2GB memory each Run Time: 360h (~15 days)

3 Tools for the acceleration and quality upgrade of the computing input generation TEC Tool™ for LS Dyna

After the model generation, the boundary conditions must be applied generally in the CAE process for the calculation, such as material properties, forces, pre-deformations, speeds, connection limit conditions, etc. With models nowadays consisting of up to 5.0 million elements, this is possible only with powerful pre-processors. However, these are not adapted to the special details of the LS Dyna software environment of the user and can support these in an incomplete manner only. Here, the software product pallet TEC Tool™, helps the user. This CAE Toolbox enables a CAE process which is as rapid and smooth as possible.
In detail, the following are involved:

- *Check routines:* The LS Dyna input files are checked for errors before the initial calculations. This verification lasts a few seconds even for very big models (5-10 Mio. Elements), unlike times up to one hour using traditional LS Dyna initialization method.
- *Visualization possibilities:* All input parameters existing in LS Dyna computing input can be visualized and changed. With the standard versions of the pre-processor programs, this is the case for only 90 - 95% of the parameters.
- *Parameter editing*: The change of computing parameters is possible in a multifaceted way. If the change comes about in the form of lists, these are checked and converted from standard formats, such as doc, xls, txt, into formats readable for the computing input.
- *Process automation:* The tools automate extensive CAE process steps, which are often defective, such as e.g. maintenance of separation distances between component parts, model assembling (bonding, hot-welding) etc. In this case, the designer also receives important information even before the actual calculation is implemented.

The increases in productivity through the employment of TEC Tool™ are in the range of 20 - 40%, according to customer statements.

Summary

The processes described are developed to speed up the mesh and input generation are they fit especially well for LS Dyna. CAE process which used to take 4- 6 weeks can be accomplished in one week (meshing and input generation) The automated meshing will result in bigger mesh sizes which require more time and effort. The process can be accomplished by using supercomputer hardware platform especially for the explicit codes.