Title:
Convenient Connection Technology Data Model Supporting Optimized Information Exchange between CAx-systems

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Introduction:
In today's increasingly and progressively globalized economy, which has produced a very volatile and ever-changing business market, it has become ever more difficult for automobile manufacturers to identify, analyze, and fulfill consumer desires and their respective expectations. This process is drastically exacerbated by the consistent and intense inter-competition between members of the automobile manufacturing industry [6]. This means that the automotive market is elevated and consolidated by innovations and inventions. One important point to achieve is increasingly shorter times to market by automating and optimizing the development processes. The average development time of a vehicle has been reduced in the past four decades from nearly seven years to pretty much about two years today [4].

Due to the advanced globalization and increasing competitive pressure, it is important for car manufacturers to find market niches, where it is possible to sell vehicles. One important influencing factor in car development includes technologies for the reduction of energy and fuel consumption, i.e. by lightweight design. On one hand, it is imperative to keep costs low and on the other hand, it is ever more important to reduce the total weight of a vehicle [5]. In the automotive industry, the number of multi-material bodies is increasing steadily. The background for this rise is, that the body weight can be reduced due to the mix of different materials, by almost the same material costs. This technology requires a high number of different kinds of connection types, which consists of a high amount of meta data. Due to the high amount of meta data, they play a crucial role in the development process, especially in terms of the CAx-environment. A big issue is the data exchange between the different areas design, analyses and manufacturing. By optimizing the data exchange process, the data quality can be improved and the data quantity can be reduced. The present paper focusses on an approach of a new data model, which deals with the storage and further processes of data, in an attempt, to further reduce the effort of data management and costs.

In this context, the present paper focuses on investigations in an important field of automotive bodywork development: the computer-aided design and layout of connection technology. As a basis, the state of art is introduced, and the different types of connection technologies in automotive body design are discussed. Subsequently, a simulation process is formulated and evaluated in view of different quality and development performance criteria to support integration of knowledge-based methods into existing design workflows [7].

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Problem Statement:

As introduced in the previous section, it is important to find an optimal solution for design automation and optimization of connection technology in the automotive industry. Since today's automotive design processes are carried out completely in computer-aided design- and simulation environment, the present approach emphasizes focusing the application in common CAx–systems (CAx – computer-aided x, where x is a placeholder, e.g. CAD, CAE, etc.). This in turn provides an enhancement of the data exchange between design, simulation and production/manufacturing development. The main issue is how is it possible to transfer connection technology data from the CAD-environment into the CAE-environment? Which file format is best suited for this transfer? How is it possible to guarantee that the transmitted information is received in the CAE-system?

Having stated that, every discipline requires various information to fulfill its development tasks. This variety of values must be collected and can be bunched together in a comprehensive data model or in a database structure. The idea of a unified data model shall be seized up in a way that it is possible to be used in all areas of application. In this context, the presented data model is based on an optimized process to decrease development costs and guarantee reduced development time in total.

State of the art:

Currently there are no standards or regulations available for a connection technology data model or how connection technology must be transferred. From the viewpoint of an engineering supplier a big issue is that projects are processed together with different OEMs. Why is this such a big problem, especially in terms of data management and data exchange? A lot of car manufacturers (OEMs) such as Renault or Opel have not clearly announced which systems, tools or processes are used in their development projects. They do not make clear specifications regarding the use of a certain software, tools, systems or processes to engineering supplier. On the other hand, there are some OEMs like BMW or Daimler, which specify the development environment and data management-related aspects with high accuracy. Consequently, this leads to the fact that a supplier must deal with different software (for example several CAD programs e.g. CATIA [https://www.3ds.com/] or NX [https://www.siemens.com/NX]). The different systems and tools are limited due to scarcity of the currently available versions on the market. Despite that, every OEM is using different data management systems and different development processes. To achieve a shorter development time, more and more applications of virtual product development are used.

According to a vehicle body, each body design starts with a general definition of the product specifications and an exterior styling proposition [10]. The next step is the body packaging development. In this phase, CAS data is transferred into CAD-environment. From this moment on, the design of the bodywork starts under a variety of technical aspects. By use of CAE-systems, the design is continually refined and due to the detection of problem areas, an optimization cycle (CAD/CAE integration process, see Fig. 1) between CAD and CAE is started [1], [11].

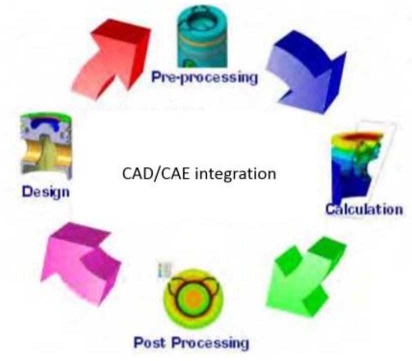

Fig. 1: CAD/CAE integration process – referring to [2].

During the whole development process this cycle runs through several times. The same cycle takes place between CAD and CAM. CAD data is transferred into a CAM-environment, where it is examined for

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production-related facets. At this juncture, the enhancements are transferred back to the CAD-environment where necessary modifications are performed [10]. An important issue in this process includes the connection technology in total. Connection technology is used to combine several components of an automotive bodywork. A favorable connection technology that is still currently in use is spot welding. Exemplary, about 5000 spot welds are applied in a mid-size car steel body (see Tab. 1 and Fig. 2).

	V90	V70	Δ
Spot welds	5250	4170	+1080
Arc weld [m]	4.9	5.5	-0.6
Laser weld [m]	4.4	5.7	-1.3
Laser braze [m]	0	1.3	-1.3
Adhesive - Epoxy [m]	0	24.9	-24.9
Adhesive - Rubber [m]	69.6	16.2	+53.4
Hotmelt [m]	7.2	19.8	-12.6
Antiflutter [m]	2.6	2.8	-0.2
Weldstuds [#]	247	190	+57

Tab. 1: Comparison of connections - Volvo V90 and V70 [9].

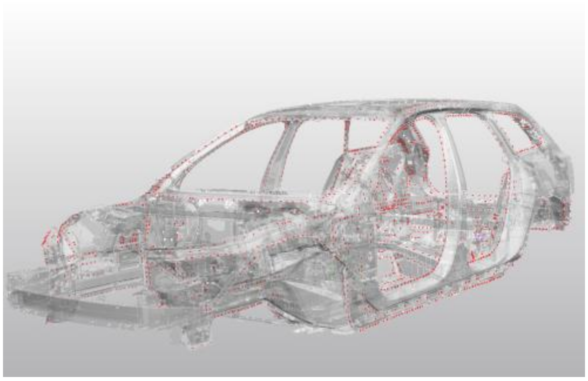

Fig. 2: Volvo V90 Car body – spot welds are displayed in red [9].

Due to this high amount of spot welds a significant effort in design, simulation and production is necessary. All required information concerning the applied connection technology in a body-in-white development process is created in the CAD-environment as a data model. This information may contain the spot weld dimensions and positions, adjacent sheet metal parts, as well as other data. This generated information is supplied to the CAE simulation process to give a useful verification of stiffness, durability and deformation behavior, for example in case of a crash scenario. The next step is supplying the CAM engineer with this CAD data model. Furthermore, the production engineer must guarantee that the accessibility of weld robots is ensured. A considerable extra effort for definition of the meta data is added to the already mentioned effort for the generation of spot welds. Regardless, meta data is important for the data model because it contains the type of connection, the number of circuits of the connection, the involved components and the material, among others. Another important issue includes the positions of the connection points, since this provides information about safety-relevant areas [11].

Approach:

Target is to create a data model, which includes the already mentioned issues and optimizes the data exchange process between the different fields in the development process. The data model should be applicable for all currently used CAx-systems and -tools within the development environment of different OEMs. The focus of the present approach lies on the connection technology of automotive multi material bodywork. Fig. 3 shows the approach by an exemplary application of weld spot development, including the main components of the data model. In an overview, the data model consists of a CAD- and CAE-environment, a Product Data Management (PDM)-system and a connection technology exchange tool that is called CTXT. The weld spot defined within CAD-environment, is transferring its meta data and geometry information to the CTXT. On one hand CTXT can communicate with the CAE-environment to forward all necessary data. On the other hand, CTXT interacts with a PDM-system to supply a data base with required information. In this way, CTXT is transferring all important data into the CAE-environment, where these data are prepared (CAE-pre-processing) for simulation processes. In the CAE-post-processing step, the simulation results are summarized and an output file is generated. After handing-out the whole CAE-process, the obtained data are fed back to the CTXT. This process can take place several times, until the CAD-model is completed and the connection technology development process is finished.

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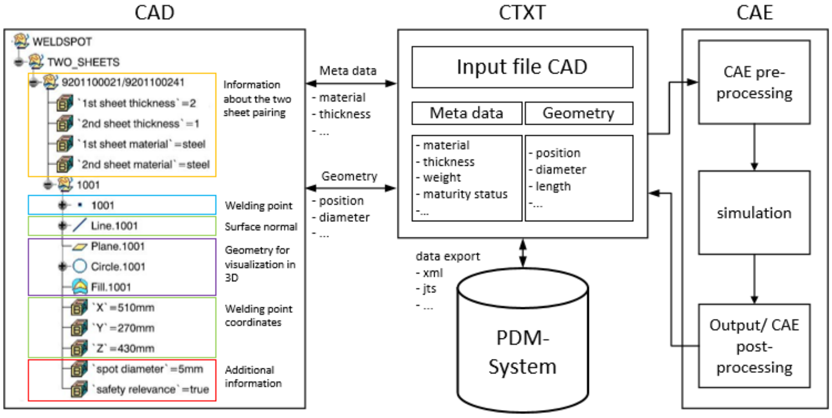

Fig. 3: General layout of a connection technology data model.

Process flow in CTXT-environment:
Fig. 4 shows how the data exchange process between CAD- and CAE-environment takes place. The CAD parts are divided into assemblies (components) and CT-parts (Connection Technology parts). Assemblies are transferred into the CAE-environment, native or through a PDM-system. In both ways - native or through a PDM-system - a JT (Jupiter Tessellation) conversion takes place.

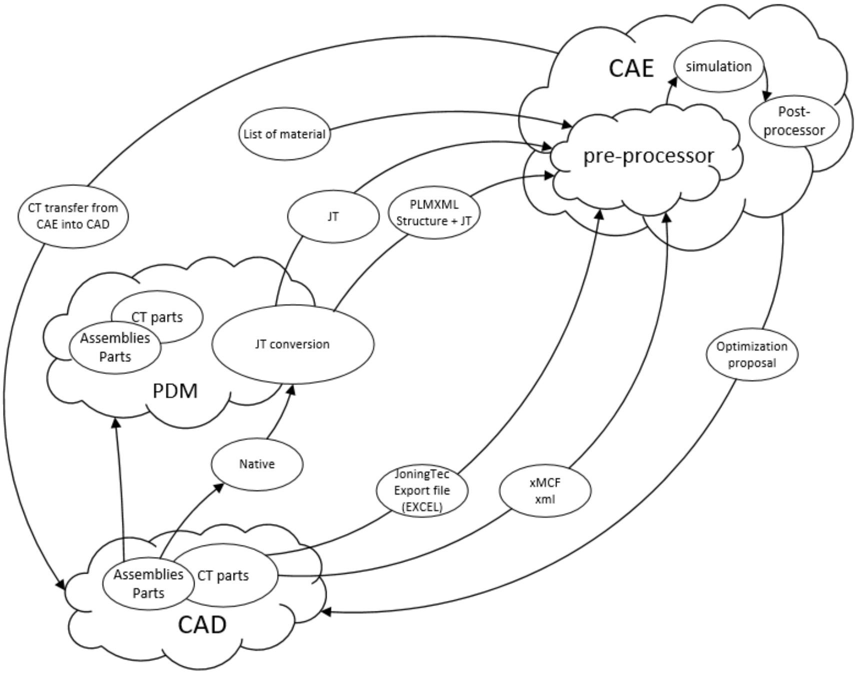

Fig. 4: Process flow in CTXT-environment.

The CT-parts are transferred into the pre-processor due to a Joining Technology Export file like Excel or xml. In this process a guarantee is given that a list of material should be addable, if necessary as well as an optimization proposal - with results from CAE - can take place. In some projects, it is possible that the connection technology data is created in CAE- instead of CAD-environment. Therefore, a possibility is given that this data can be transferred into CAD.

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Necessary data and classification of relevant connection types:
Every type of connection technology is characterized by different parameters and attributes. Tab. 2 gives an exemplary overview for a spot welds and describes which data is needed by a design engineer (CAD), by an analyses engineer (CAE) and by a production engineer (CAM).

CAD	*CAE*	*CAM*
coordinates (x, y, z)	coordinates (x, y, z)	coordinates (x, y, z)
diameter	diameter	diameter
	material	material
		surface normal
		technology (laser, friction welding, …)
		manufacturer of welding device

Tab. 2: Necessary information by an example of spot welds.

In the example shown in Tab. 2 spot welds are completely described by their coordinates (x, y, z-coordinate), diameter, material, technology and some additional parameters, e.g. type and manufacturer of welding device, required current density for welding, etc.

Apart from spot welds, every type of connection technology needs its own attributes and parameters to be clearly characterized. As already mentioned, the data model shall be useable for different OEM systems. A big issue is that every manufacturer uses/prefers different types of connection technologies. This leads to the fact that the data model must be able to contain every currently used connection technology on the market. If this is not the case, it can lead to a problem in the data flow between design, analyses and manufacturing. The various kinds of connection technologies differ from each other by their geometrical shape, manufacturing process, material, mechanical properties etc. In the data model a distinction is made between the following three types of connection technology [3]:

- 0d-connections: spot welds, rivets, bolts, screws, ...
- 1d-connections: seam welds, adhesive lines, hemming flanges, …
- 2d-connections: adhesive faces, …

Conclusions:
Due to the progressing globalization in automotive industry, it is more important than ever to automate the processes for design, simulation and manufacturing. This automation results in a considerable acceleration of production development and can also increase the process reliability. In conclusion, it can be mentioned that there is a high potential for optimization of the data exchange process, especially in the field of multidisciplinary development of connection technology.

A possible way to optimize the information exchange process is provided by the implementation of a unified data model. This data model gives a good leverage point for a smart integration of knowledge-based design methods and design automation. The target is to improve data quality and reduce data quantity due to a tool, called CTXT. This tool is working with file formats for the data exchange, which are compatible for all tools applied within the CAD-, CAE- and CAM-environment. Data quality plays an important role; each conversion is an additional error source. Therefore, a very important reason for a unified data model is, that there is no necessity for extra conversion i.e. neutral file format [3].

By introducing a new approach for a comprehensive connection technology data model, the findings of the present contribution can support the enhancement of automotive bodywork development processes. Frequently data freezes take place in the field of connection technology. A unified data model must guarantee that every engineer, no matter in which domain (CAD, CAE ...) receives the same data status.

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References:
[1] Boniz, P.: Freiformflächen in der rechnerunterstützten Karosseriekonstruktion und im Industriedesgin, Springer, ISBN 978-3-540-79440-0, 2009.
[2] Chamoret, D.; Roth, S.; Badin J.; Imbert J.; Gomes, S.: Crash FE Simulation in the Design Process - Theory and Application, Prof. Jan Awrejcewicz (Ed.), ISBN: 978-953-307-389-7, InTech, http://www.intechopen.com/books/numerical-analysis-theory-and-application/crash-fe-simulation-in-the-design-process-theory-and-application, 2011.
[3] Economidis, N.; Franke, C.; Golumba, J.: xMCF – A standard for describing connections and joints in the automotive industry v3.0, Berlin, FAT- Forschungsvereinigung Automobiltechnik e.V., 2016.
[4] Hirz, M.; Dietrich, W.; Gfrerrer, A.; Lang, J.: Integrated Computer-Aided Design in Automotive Development, Berlin, Springer, ISBN 978-3-642-11939-2, 2013.
[5] Hirz, M.; Rossbacher, P.: Enhanced Knowledge-based 3D-CAD methodes supporting automotive Body-in-white production engineering, Management of Technology – Step to Sustainable Production (MOTSP 2016), Croatia, 2016.
[6] Kreis, A.: Design and simulation of a vehicle side panel frame to establish a flush glass look, Master Thesis, Graz University of Technology, 2016.
[7] Mayer, J.: Strategien zur Weiterentwicklung der wissensbasierten Konstruktion, PhD Thesis, Graz University of Technology, 2015.
[8] Meywerk, M.; CAE-Methoden in der Fahrzeugtechnik, Springer, ISBN 978-3-540-49866-7, 2007.
[9] Nedic, S.; The all-new Volvo V90 car body, EuroCarBody 2016, Bad Nauheim, 18-20. October 2016.
[10] Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, K.-H.: Engineering Design: A Systematic Approach, Springer, ISBN 978-1-84628-318-5, 2007.
[11] Thum, K.; Hirz, M.; Mayr, J.: An integrated approach supporting design, simulation, and production, CAD'13, 11(4), 2013, 411-416, http://dx.doi.org/10.1080/16864360.2014.881183.

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