Evolutionary Design in Chassis Technology

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Abstract

This paper details the use of the Thyssenkrupp eDICT process for the design of sheet metal chassis components. eDICT (evolutionary design in chassis technology) is an innovative structured process flow for the design of optimal structures. eDICT uses the optimisation capability of Optistruct with a set of custom tools to guide and translate a design into a production feasible sheet metal solution. Fundamentally it reverses the usual design loop of CAD first then CAE assessment. The function is used to determine the design and the form follows. On recent projects eDICT has produced 25% mass reductions compared to the current series design. eDICT is also able to reduce development times and resource with an efficient solution production right from the outset.

Keywords: Optimisation, Sheet Metal, Topology, Vehicle, Chassis

1.0 Introduction

ThyssenKrupp Tallent is a world class design, developer and manufacturer of leading edge, innovative chassis structural and suspension products, modules and systems for the global automotive industry. TKT supplies some of the biggest names in Industry including: BMW, Ford, General Motors, Honda, Jaguar, Land Rover, Nissan, Porsche, Renault, Saab, Volkswagen

Specialised Products include: Front and Rear Subframes, Rear Axles and Twistbeams, Module/System Assemblies, Front Lower Control Arms, and Susupension Links.

ThyssenKrupp Tallent Ltd has adopted the HyperWorks CAE platform as an enterprise simulation solution for design, optimization and virtual manufacturing of their automotive chassis components. The flexibility of HyperWorks has proved instrumental in the design of chassis components, subframes and suspension arms in which optimization has been used throughout to improve component performance while maximizing efficient material utilization.

This paper introduces how HyperWorks driven processes have been encapsulated in a set of automation tools (eDICT, evolutionary Design in Chassis Technology). To facilitate the compute intensive requirements of optimization TKT has commissioned advanced cluster systems (Altair OptiBox) controlled by Altair PBS professional load management.

The traditional design method for most structural components is NOT function led in the first instance. The very first CAD design is made with little or no specific functional input and then assessed in CAE and fixed where necessary. This process loops through multiple design iterations with the design becoming more structurally efficient, but the optimum solution is never known. This is a lengthy process and produces sub-optimal (heavy and expensive) parts, normally package and design for manufacture led. To achieve minimum weight we must change the design method to be function led (ie material only where it needs to be.)

The critical first step in eDICT is to determine the optimum solution from the outset and place material only where it is needed.

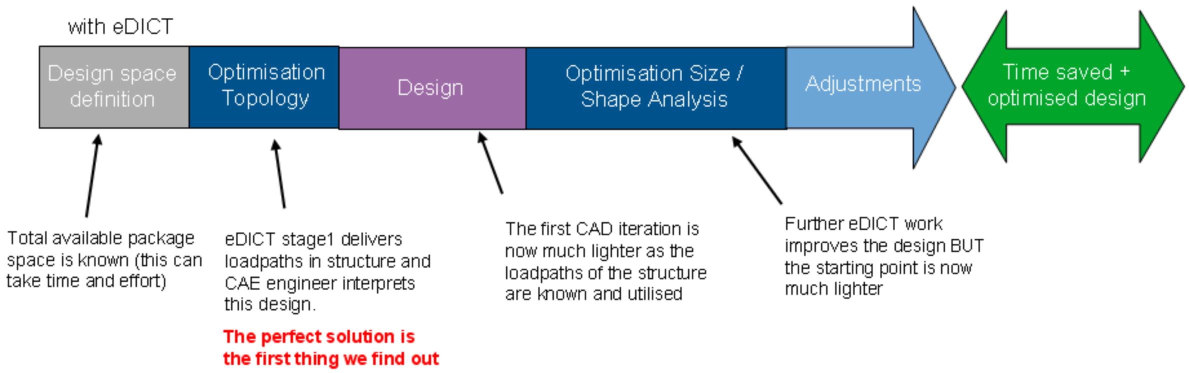

Figure 1: The Design Approach using the eDICT Process

This means the first CAD design is light and the designers are now guided by the function of the part. The perfect structural solution is known.

2.0 How the eDICT method works

2.1 The Perfect Design

The eDICT process begins by generating the optimum solution; know as the 'skeleton'. The challenge was to transform this skeleton into a sheet metal equivalent without losing performance or increasing the design mass.

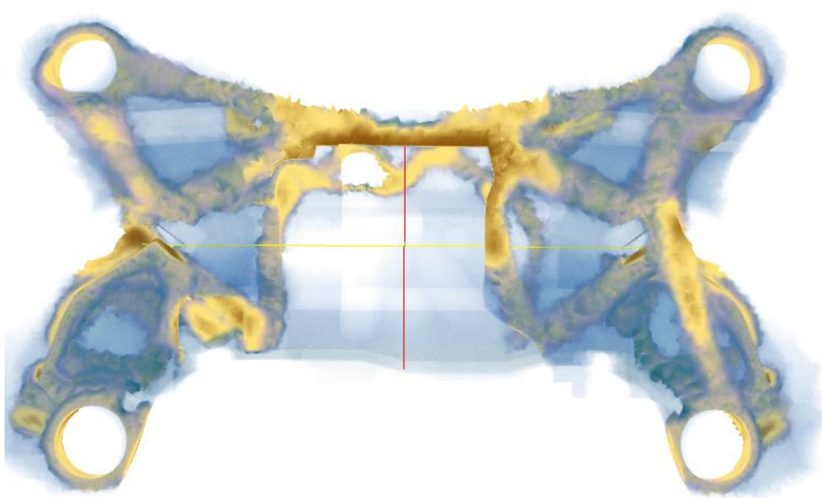

Figure 2: The 'Skeleton' Inside the Package Space. The Perfect Design.

Unique techniques developed alongside powerful mathematical algorithms have made this transition a relatively easy step.

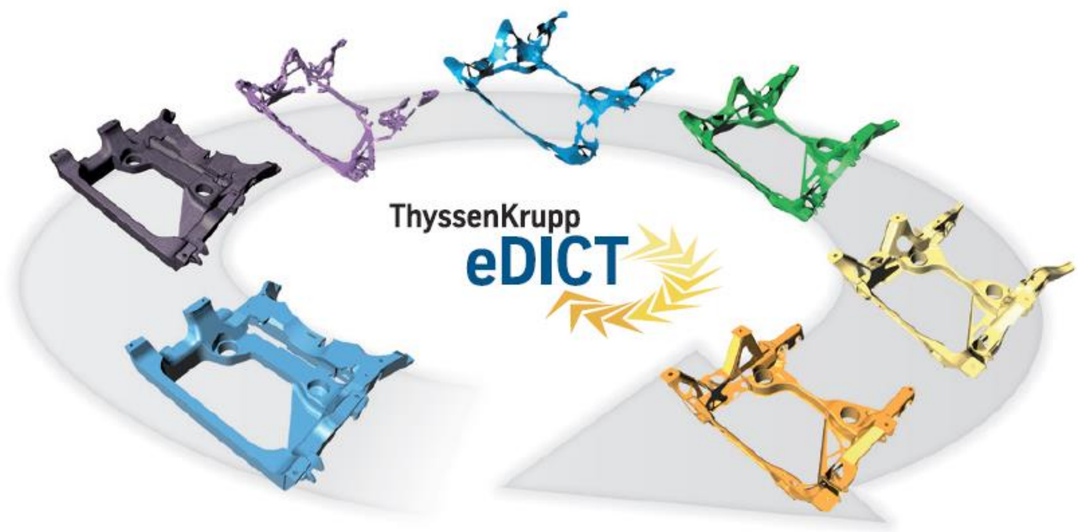

Figure 3: The eDICT loop from Package Space to Production.

2.2 The eDICT software

The eDICT software has been developed with Altair Engineering Ltd, in order to provide a simple user interface for the process. The open architecture of HyperWorks allows custom interfaces to streamline the process and guide the user along the path of best practice. This Hypermesh plug-in takes the user through four stages of development as well as tracking the efficiency of the design and highlighting the driving factors which are adding mass into the solution.

The eDICT software includes new mathematical algorithms developed to analyse the skeleton. The unique 'planefinder' algorithm robustly outputs planar regions representing portions of a mechanical part that can be built using sheet plate.

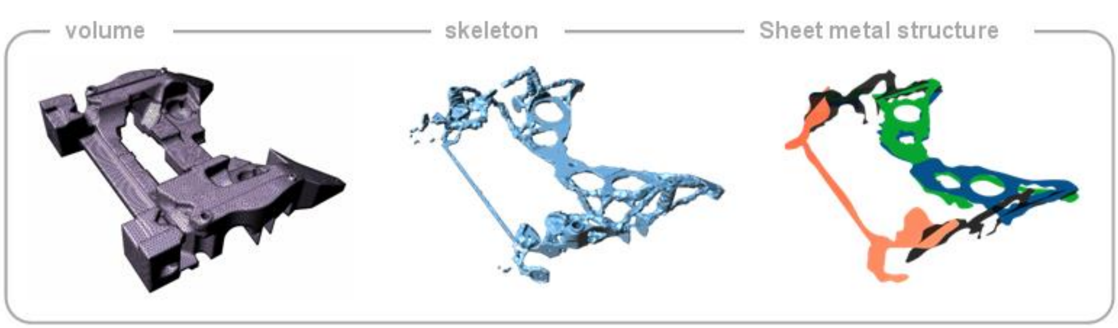

Figure 4: The Planefinder Algorithm Identifies Planar Regions in the Optimum Solution.

The second ‘optianalyzer’ algorithm is used to analyse the density results from a topology optimisation density output, and determines an equivalent sheet solution to the solid skeleton like structure.

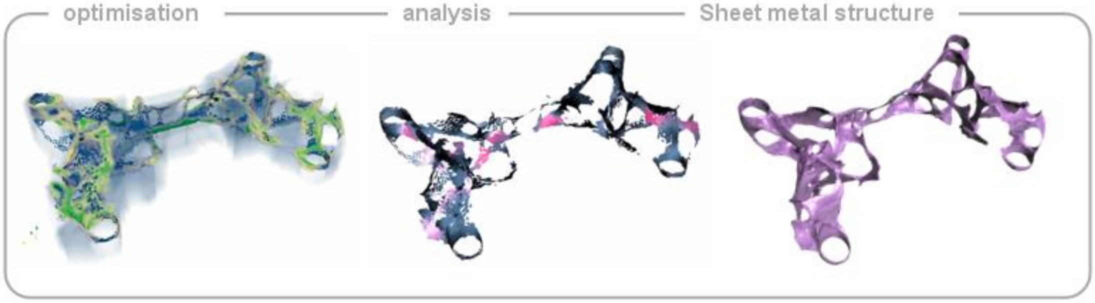

Figure 5: The Ooptianalyzer Algorithm Generates a Sheet Metal Representation of the Optimum Design.

These tools guide the designer showing exactly where sheets should be positioned to give the most efficient solution.

3.0 The Benefits of eDICT

3.1 Reduce Mass

Recent projects using eDICT have shown a 25% mass reduction when compared to a conventional design.

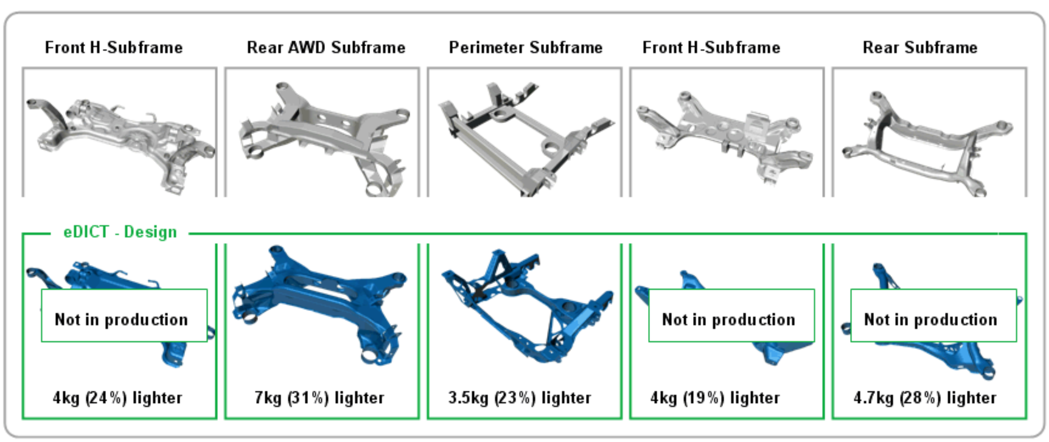

Table 1: The Results of eDICT used on 5 Recent Chassis Projects.

Some of the key advantages of the eDICT process are for reduction in mass:

- The eDICT structural components are near optimum for the material used and give a minimum mass solution this contributes to better fuel economy, lower vehicle taxation and lower CO_2 emissions.
- eDICT can also take advantage of the latest ultra high strength steel when used at thin gauge to give further mass opportunities.

- eDICT can and has been used to produce a steel design solution that is comparable in mass to competitors' aluminium designs.

3.2 Reduce Cost

The eDICT design process contributes to cost reduction by facilitating:

- Lower part cost due to a reduction in raw material cost ~ 10% overall reduction.
- 70% of the part cost is fixed at the Design Stage **[1]**, eDICT keeps this to a minimum.
- eDICT produces a near optimum solution in a reduced period of time reducing overhead.
- Identifies the package drivers for the design very quickly ~ assists customers in fighting for package space to maximise efficiency and reduce unnecessary cost and mass

3.3 Efficient and Fast

The design development process is compressed through strong integration between CAD and CAE and the following factors:

- Quantified efficiency of component design, the customer knows exactly how good their design is compared to the optimum, and the competition.
- The eDICT design approach greatly reduces the need for redesign by using a 'right first time' approach, leading to a reduced development phase.
- During vehicle programme, allows very quick analysis of implications of package and/or target changes, the traditional method requires a re-design for this to be assessed (slow).
- Each design can be compared with the perfect design (which is only known using eDICT) to give an efficiency measure for each design.

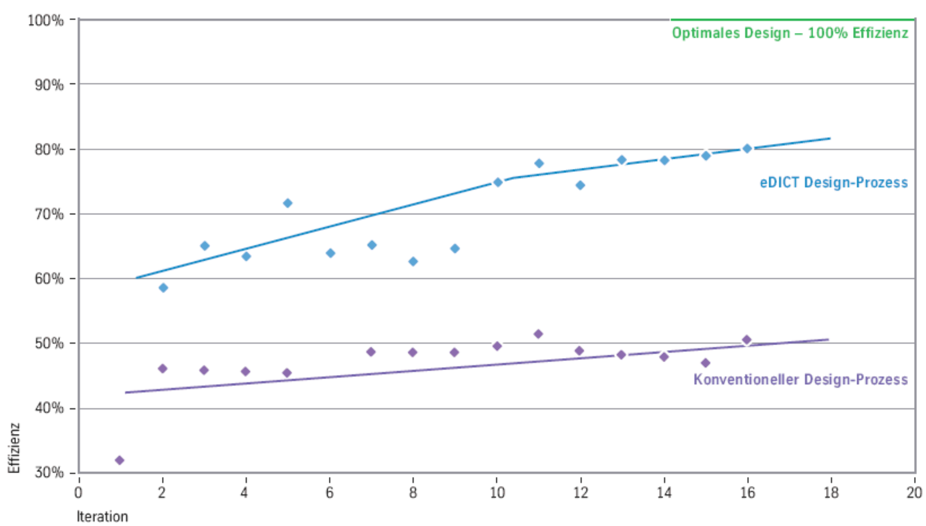

Figure 6: The eDICT Design Approach Compared to a Benchmarked Conventional Design Development History.

- The first eDICT design iteration has a much higher efficiency compared to that of a structure, designed using the standard approach.
- Rapid improvements in performance are made in a short number of iterations by using the eDICT approach.

4.0 Conclusions

- The use of the eDICT process flow, when carried out rigorously, provides significant rewards for chassis component design. Potential greater rewards may be possible at system level where trade-offs are possible.
- ThyssenKrupp are leading the way in translation of optimum topology solutions into feasible designs, this is eDICT.
- Ideas are being constantly developed for further developments to the process and Thyssenkrupp are determined to stay at the leading edge of vehicle design optimisation.

5.0 References

[1] **'Current & Future Technologies in Automotive Engineering Simulation (CAE)'**, AUTOSIM Consortium, NAFEMS 2008.