HEXAGON | MSC Software

White paper

Smart manufacturing: Reducing costs through virtual simulation

Recognizing optimization potential in product development and implementing in the manufacturing process

Digitalizing manufacturing

Industry 4.0 has been a topic for over a decade, present in public discussion and determined in the top management agenda for many companies. Central here is the transformation process from individual, human-controlled production steps to connected, digitalized production.

Figure 1: Smart manufacturing creates seamless digital connections between functions, leading to intelligent processes

Manufacturers are looking for intelligent solutions to increase quality and productivity. Hexagon helps companies digitally transform manufacturing processes, seamlessly connecting data from throughout the process and converging the real and digital worlds to drive continuous improvement. Hexagon's Manufacturing Intelligence division provides solutions that utilize data from design and engineering, production and metrology to make manufacturing smarter. This paper focuses on the area of design and engineering, which deals with the development and validation of the virtual model design of a component up to manufacturability.

In addition, this paper deals with the identification and implementation of optimization potential in product development and in the manufacturing process. This leads to increased quality and productivity in the manufacturing process and to cost savings along the manufacturing chain, see Figure 2.

Where do the costs arise?

The development and production planning departments are responsible for up to 90 percent of the lifecycle costs of a product – and that at a point in time when a component does not even physically exist. It is therefore necessary to take all measures possible early in the process to enable robust, error-free and economical production.

The use of numerical simulations plays an important role here: physical tests of products or processes are replaced by virtual experiments on the computer, which drastically reduces the production costs of prototypes. In addition, they reduce product development and delivery times through analysis and validations on the virtual model, and improve product quality.

For the success of manufacturing companies, virtual manufacturability analysis and simulations of the production process prior to the actual production are of critical importance. Because changes to the product or production process are often associated with very high testing and approval efforts the costs can quickly increase immeasurably.

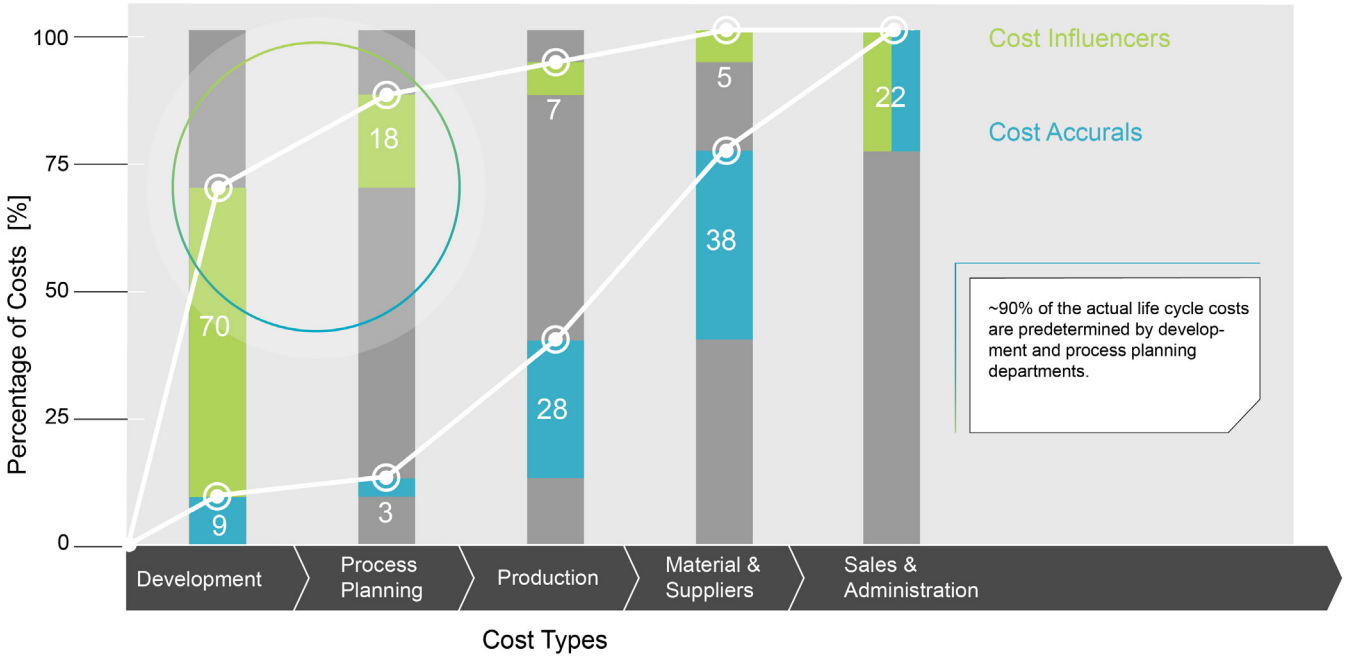

Figure 2: Percentage cost share of the cost types along the production chain (own illustration, source: Ehrlenspiel, TU Munich)

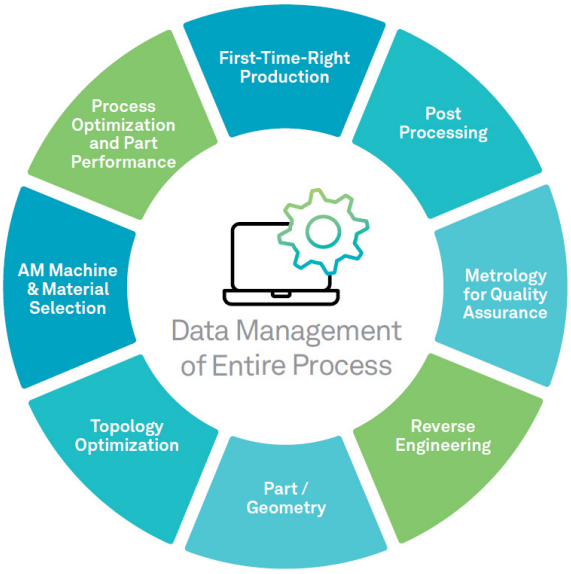

Figure 3: Sub-processes are linked through integrated data management

In practice, savings in process and development costs of around 50 percent can be achieved. Production costs can be reduced by up to 30 percent through better machine utilization, optimized stage sequences, more sustainable material use and less set-up effort. Quality indicators are improved by reducing scrap and rework by over 20 percent.

The virtual development chain with MSC Software

The development process involves a large number of simulation tasks along the development chain. By using specialized tools for each individual development step, the development can be implemented efficiently and cost-effectively. Hexagon connects the previously isolated specialist disciplines from design to manufacturing to the final quality inspection.

Value Engineering

Manufacturing and downstream processes consume over 90 percent of total lifecycle costs; however, up to 70 percent of these costs are driven by decisions made early in the product creation process. Before significant investments (tools, systems, or equipment costs) are made, material costs, manufacturing costs and feasibility can be determined in the design phase. This process is known as value engineering.

FTI's FormingSuite software provides solutions for early feasibility assessment and cost calculations for sheet metal parts. Using this software solution at a very early stage of product development allows designers to determine and understand the material and manufacturing costs associated with their design enabling components to be constructed cost effectively, eliminating geometrically caused cost drivers early on. Simulation also addresses potential problems with manufacturability by identifying formability issues early in the design process. This allows the designer to design the component first-time right. Designers can analyze the component feasibility, optimize the geometry, and avoid costly design changes later in the manufacturing process (see Figure 4).

Minimize development time

One of the crucial aspects in advance of and during production is time. With simulation software, engineers can identify production problems before manufacturing, which they can also correct in the simulation. This significantly reduces process changes and tool change loops in the production process. In addition, fewer prototypes are required.

In order to minimize lead times and development time, Digimat software offers an accurate simulation of fiber-reinforced

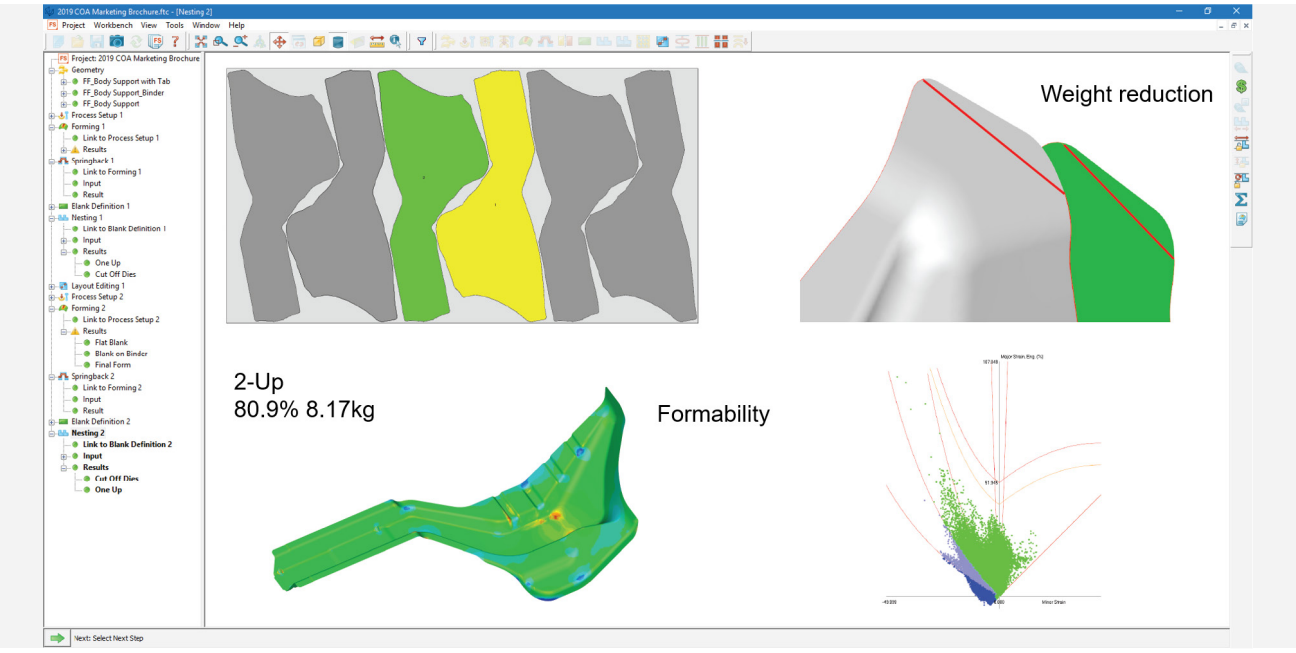

Figure 4: With FormingSuite, potential problems with manufacturability can be identified during component design

plastics. For example, the classic development time for a component that dampens the vibration of an automobile is around one and a half years – with the first 16 weeks alone being devoted to design and process development. To shorten this cycle significantly, the calculation is carried out with Digimat. The number of design changes can be reduced by up to 70 percent, as very precise simulation results are already available.

In addition, processing conditions are of essential importance for the component behavior, in order to avoid imprecise estimates. With Digimat it is possible to carry out a very precise first structure simulation within a few minutes and to add a simple process simulation.

The simple operation of the software reduces the preparation time for the engineers. The analysis of a component variation can be reduced from one week to just 15 hours, prototypes can be developed earlier, and production can be achieved much faster (see Figure 5).

Service life and durability

Predicting material failure and fatigue is one of the most difficult tasks in product development. The costs of the physical tests can quickly reach five-digit amounts and more. Numerical simulation methods calculate the service life and represent safe operating loads and curves for warranty cases.

In addition, the effects of high temperatures, manufacturing processes and stresses in the assembled state are examined. The simulation enables precise predictions of service life and fatigue under any conceivable combination of time or frequency-dependent load conditions.

Case study: virtual development chain in the construction of a wheel carrier

The following case study was carried out with the Formula Student Team from the University of Paderborn, showing the use of different simulation tools that build on one another.

The task of the project was to replace a conventionally cast and machined aluminum wheel carrier with an additively manufactured variant. The additively manufactured variant should not only achieve the same performance as the conventional design, but a further weight reduction of the component should also be achieved simultaneously.

Figure 7 represents the complete virtual development chain based on the workflow for a wheel carrier.

The installation space, load connection and mounting points were known from the original design. A multibody simulation with MSC Adams provided the main load cases. With this information, a weight-optimized component could first be calculated. With MSC Apex Generative Design, different variants with an average weight saving of almost 50 percent were made available for further studies. Another advantage of the software solution used was that during the design process, manufacturing aspects and boundary conditions are incorporated into the solution. This creates a “production-ready” design.

The possible design candidates could then be examined in Simufact Additive for possible manufacturing problems and their effects on manufacturing costs. All relevant factors influencing the costs are stored in a corresponding cost model and make it possible immediately to show the influence of a process change on the construction costs.

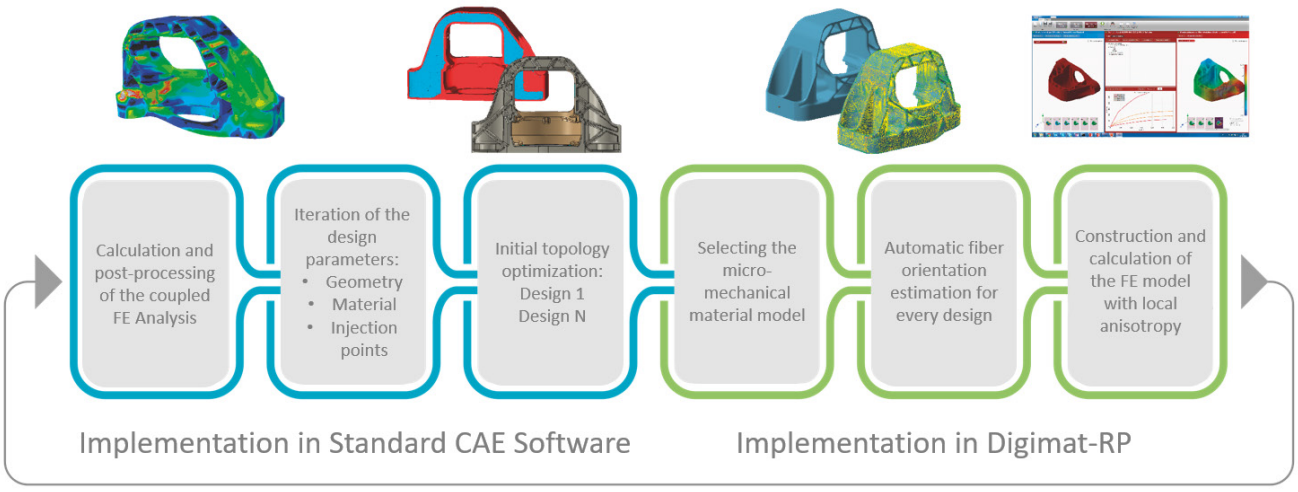

Figure 5: Shortening the analysis of a component variation with Digimat

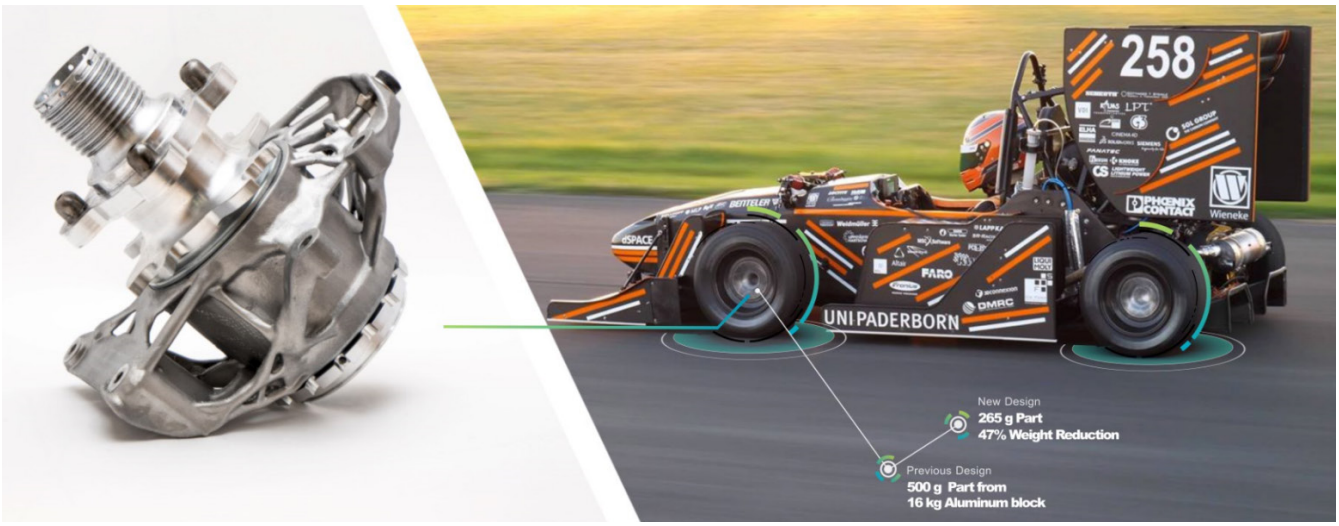

Figure 6: Aluminum wheel carriers, virtually optimized and developed, installed in the Formula Student car at the University of Paderborn

The selected manufacturing process is simulated, and all dimensional deviations and typical construction defects, that would lead to the construction being halted or to faulty components, are examined.

The results of the calculation were passed on to MSC Nastran for the structural calculation and MSC Adams for the multi-body simulation for a final validation. This serves to safeguard the component behavior when installed under operating load.

All local property changes that occur during production, depending on the selected manufacturing parameters, are included in this final check.

At the end of the process chain, there was a finished component and process design that not only meets the technical specifications, but also guarantees an economical cost framework.

Virtual Lifecycle Manufacturing – the virtual production process

As described earlier, Industry 4.0 describes a digitally networked working environment along the entire value chain. For this reason, MSC Software is currently working on the implementation of a strategic solution platform within the framework of smart manufacturing: Virtual Lifecycle Manufacturing.

Virtual Lifecycle Manufacturing helps to achieve further cost savings and quality improvements through a combination of different software solutions. The targeted use of production simulation solutions in the early development stages plays a central role.

Measurement data from real processes are usually only available for an evaluation and analysis of process and product quality when prototype tests or production are

Figure 7: (1) Identification of the load cases with MSC Adams (2) model configuration with MSC Apex Generative Design (3) selection of suitable design candidates after optimization, (4) Simufact Additive Manufacturing simulation with cost optimization, (5) structural analysis with MSC Nastran (6) with MSC Adams, (7) manufacturing by service providers, and (8) CT scan and quality check with Volume Graphics

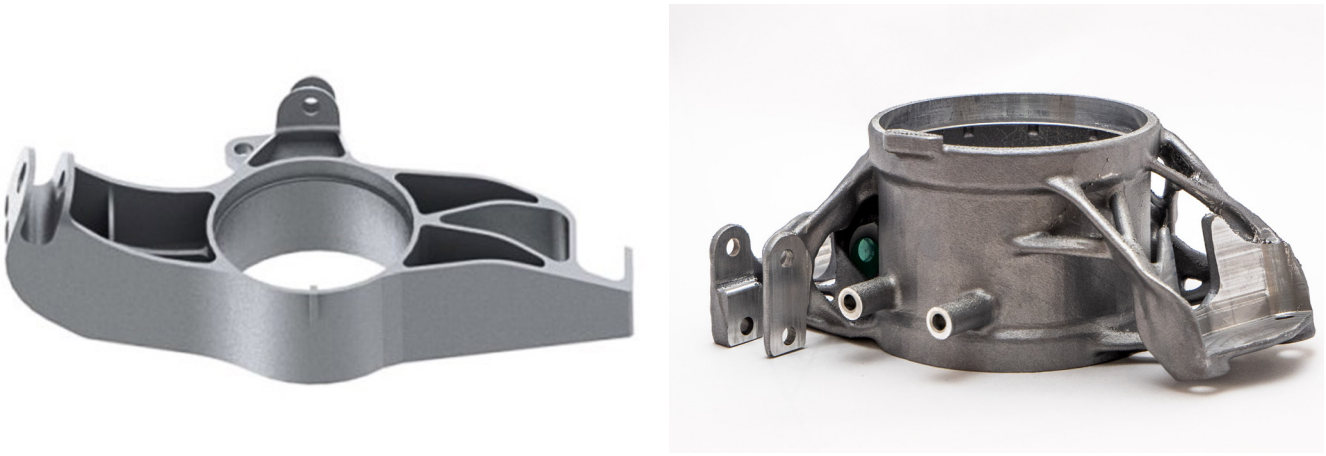

Figure 8: (Left) previous version with classic milling design (Right) AM design optimized for cost and weight

started. With Virtual Lifecycle Manufacturing, virtual measurement data is generated from the production simulation using intelligent software solutions and processed and analyzed using the same methods and in the same data and quality management system as real measurement values.

In addition, the real measurement data can also be read in, thereby enabling a direct comparison with the virtual measurement parameters and the nominal CAD data due to the uniform evaluation logic and analysis. All virtual measurement data from the simulation and the physical measurement data can then be recorded, analyzed and documented in the integrated solution platform. This extensive collection of data provides the basis for developing simplified models with artificial intelligence or machine learning in order to quickly obtain information and feed it back into the process.

Hexagon‘s goal is to offer this platform as a scalable solution in the near future in order to enable customers in the medium-sized supplier industry to have faster access to Industry 4.0.

Hexagon is a global leader in sensor, software and autonomous solutions. We are putting data to work to boost efficiency, productivity, and quality across industrial, manufacturing, infrastructure, safety, and mobility applications.

Our technologies are shaping urban and production ecosystems to become increasingly connected and autonomous – ensuring a scalable, sustainable future.

MSC Software, part of Hexagon's Manufacturing Intelligence division, is one of the ten original software companies and a global leader in helping product manufacturers to advance their engineering methods with simulation software and services. Learn more at mscsoftware.com. Hexagon's Manufacturing Intelligence division provides solutions that utilise data from design and engineering, production and metrology to make manufacturing smarter.

Learn more about Hexagon (Nasdaq Stockholm: HEXA B) at hexagon.com and follow us @HexagonAB.