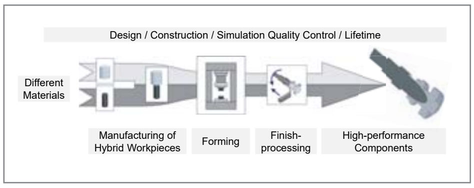
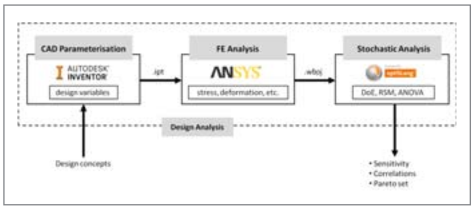
Leibniz Universität Hannover

Mechanical Engineering

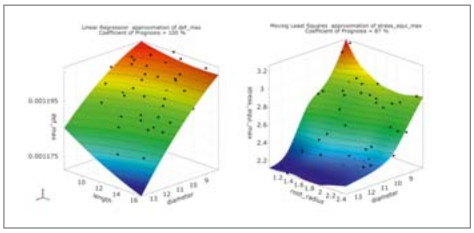
GENERATIVE DESIGN ANALYSIS FOR HYBRID COMPONENTS



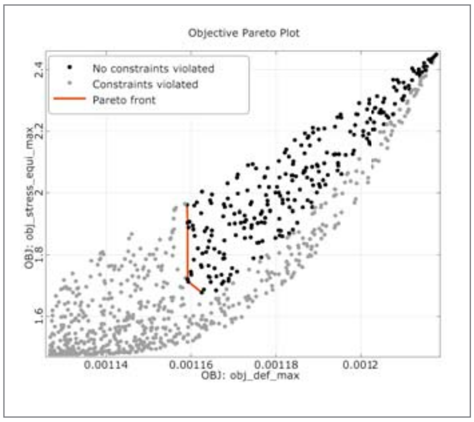
Manufacturing of Hybrid Workpieces



Design Analysis Interface



Response Surfaces of different parametrisation approaches



Pareto plot of optimal designs

Motivation

In recent years, steadily increasing demands on technical components have been observed. For this, innovative and above all holistic lightweight construction approaches are required. While materials such as steel, aluminium and plastics are individually developed further, more and more engineers and manufacturers are looking for the optimum in hybrid or multi-material construction. One of these new hybrid construction methodologies is Tailored Forming, a process-chain that involves a primary connection between work-pieces from different metals, followed by other forming and machining processes. In the SFB 1153, optimal design forms for components such as shafts are derived from a virtual test series. Thus design catalogues are created on the basis of these results.

Method

A bidirectional interface with Ansys Workbench and Autodesk Inventor allowed the determination of mechanical system responses of the hybrid shaft using a finite element analysis without a file conversion of the CAD model. The parameterization of the shaft geometry could be retained and imported into the Ansys Workbench parameter manager. The interface was supplemented by the CAE environment optiSlang. With that, the generation of parameterized geometries via stochastic evaluations and different parametrization strategies, the construction of the system responses equations and the sensitivity analysis were all executed within one single platform.

Results

A design analysis based on an automated association of CAD and FEM software with stochastic tools is well suited for parametric and sensitivity studies. The proposed method provides engineers with a flexible and robust tool to help establish guidelines such as design catalogues for hybrid components.

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iPeG SFB 1153

9T LABS

Additive Manufacturing

THERMAL ANALYSIS OF AN EXTRUSION NOZZLE FOR CONTINUOUS FIBER COMPOSITES

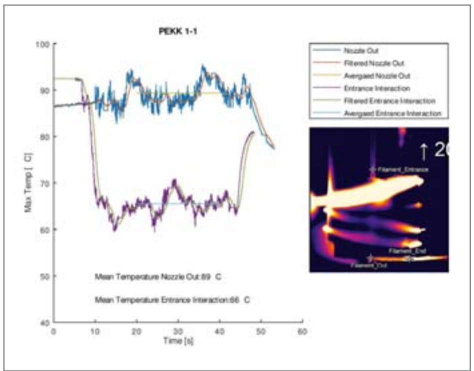

Fig. 1: Signal for calibration from IR measurements

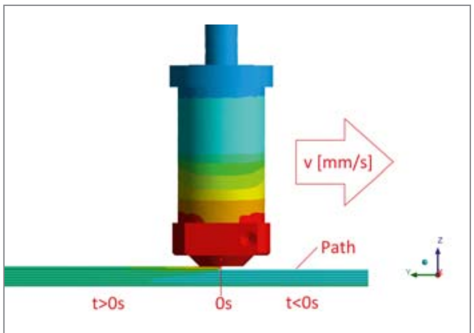

Fig. 2: Calibrated process simulation

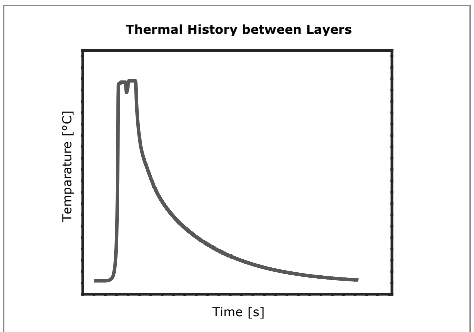

Fig. 3: Thermal history between layers

9T Labs offers a commercial 3d printing technology which enables the tooling-free manufacturing of carbon fibre reinforced materials. The system allows the processing of continuous fibres that can be printed to reinforce parts in all spatial directions (x, y, z), while also achieving high fibre volume contents (>50%). The extrusion process is one of the key steps of the printing process, and the design of the extrusion nozzle provides the basis for an exact thermal management of the extruded material. In order to understand in detail the process conditions, a calibrated thermal FE-model is built to closely resemble the thermal behaviour of the components of the system as well as the composite feedstock passing through the nozzle.

The process of solving this task is divided into two steps:

1. Calibration of test setups First, a sensitivity analysis was performed in order to understand the behaviour of the FE-Model and to generate a Metamodel and, second, an optimizer was used to minimize the deviations between the simulation models and the thermal temperature recordings (see Fig. 1). At the calibration of the test setup, values for thermal contact conductances were identified. These represent the heat transfer between selected parts of the 3d printer and the filament, this included convection as well.

2. Process Analysis With the calibrated model, a sensitivity analysis of the processing nozzle was carried out. In contrast to the calibration the varied variables were this time processing parameters such as printing velocity, amount of layer on and next to each other. Using these insights, a global simulation of the interlaminar bonding behaviour while printing was established. The combination of the thermal models, a predefined mass flow and the full print history, allowed the simulation of the temperature transient at each bonding point. This information paired with a material model allow to get a conclusion on how the bonding behaviour can be influenced by changing geometrical conditions or process parameters.

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Fraunhofer IWU

Mechanical Joining

OPTIMIZATION OF FLEXIBLE TOOLS FOR SELF-PIERCE RIVETING WITH SEMI-TUBULAR RIVET

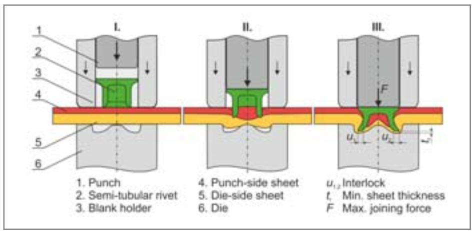

Fig. 1: Self-Pierce Riveting with Semi-Tubular rivet: process and output characteristics

Nr.	Part 1 (punch side)		Part 2 (die side / middle sheet)		Part 3 (die side)		Total
	Material	t_1 (mm)	Material	t_2 (mm)	Material	t_3 (mm)	t_{total} (mm)
1	EN AW-5182	1.25	CR380YLA	1.30			2.55
2	CR440Y780T-DP	1.00	EN AW-5182	1.50			2.50
3	EN AW-5182	1.25	EN AW-5182	1.25			2.50
4	EN AW-5182	1.50	CR240YLA	1.75			3.25
5	EN AW-5182	1.50	EN AW-5182	2.00			3.50
6	EN AW-5182	2.00	AlSi10MnMg	2.00			4.00
7	EN AW-5182	1.50	EN AW-5182	2.00	EN AW-5182	2.00	5.50

Fig. 2: Seven sheet combinations of the investigation

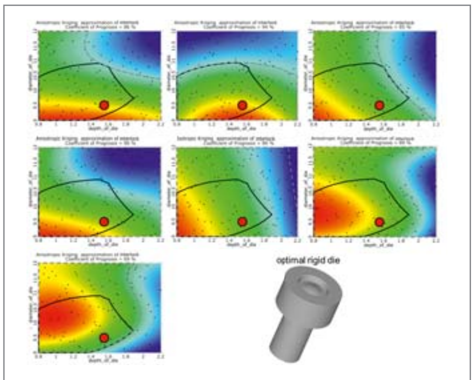

Fig. 3: Metamodels of all seven sensitivity analyzes and optimized rigid die design

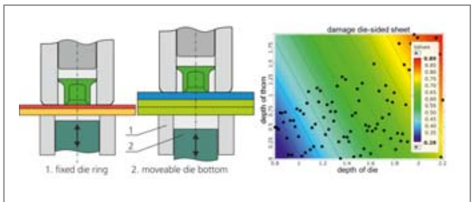

Fig. 4: Moveable die concept (left), metamodel to minimize the risk of damage die-sided sheet (right)

Introduction

The Self-Pierce Riveting with Semi-Tubular rivet (SPR-ST) process (Fig. 1) is one of the most important mechanical joining techniques, especially in modern car body constructions. Up to now a specific material combination to be joined needs individual designed tools. In order to get an efficient process, a method to compute flexible dies with the help of validated numerical simulations is the subject and aim of the presented project. Seven different sheet combinations, higher and high strength steels, aluminum sheets and die cast, two and three blank joints are part of the investigation (Fig. 2).

Compromized design with overlapping metamodels

For each of the seven joints an individual sensitivity analysis based on numerical simulations is executed. The top views of the metamodels regarding the interlock are shown in Fig. 3. The critical range of $u_{1,2} \geq 0.15$ mm should be reached at least for every joint (dashed area). The continuous line shows the zone where all joints reach the minimal requirement with same settings. With respect to the other output parameters $t_r \geq 0.12$ mm and $F \leq 60$ kN the red circle marks the optimal rigid die design.

Moveable die to increase flexibility

When joining the die-sided aluminum die cast with this rigid tool, cracks occur. So the concept of a moveable die (Fig. 4, left) is used to join all seven sheet combinations without tool changing. Depending on each sheet combination the depth of die can be fixed at an individual position before the process. With the knowledge of the metamodels a flat die is optimized, in order to minimize the risk of damage (simulated criterion: normalized Cockroft & Latham) of the aluminum die cast (Fig. 4, right). In both cases, optimized rigid and moveable die, the number of required tools can be reduced. Thus the SPR-ST process is more efficient and flexible. The developed method can be used for other sheet combinations with only low effort.

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ISM+D

Institute of Structural Mechanics and Design
Institut für Statik und Konstruktion

Research

CAVITATION EFFECT IN RUBBER-LIKE MATERIALS: IFEM-APPROACH FOR MATERIAL PARAMETER ID

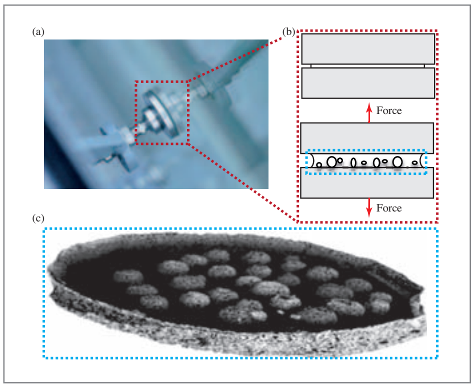

Fig. 1: Illustration of cavitation effect in point fixing connections in modern glass facades

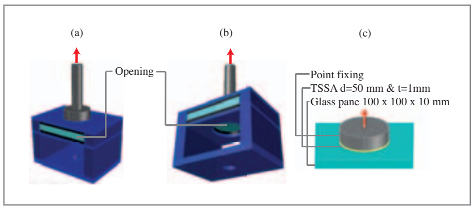

Fig. 2: Experimental test device and sample to analyze cavitation in transparent structural silicone adhesives

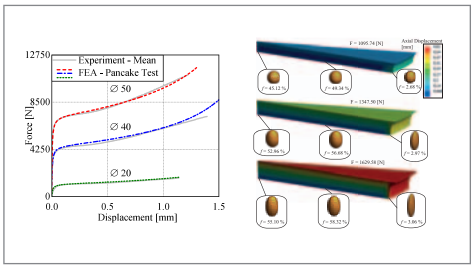

Fig. 3: Numerical validation of cavitation effect for three different diameters of the pancake test using a novel volumetric Helmholtz free energy function

Introduction

Cavitation in rubber-like materials is commonly known as sudden void growth under hydrostatic tension until material failure occurs (Fig. 1). Experimental investigations of adhesives, e.g. structural silicones accounting for cavitation in combination with the numerical treatment of this phenomenon are rare. Accordingly, experiments were performed analyzing a structural silicone under uniaxial tension as well as so-called pancake tests and compared with a new developed volumetric constitutive model accounting for isotropic cavitation.

To observe qualitatively cavitation during experiments, a new testing device was developed. In Fig. 2, the test set-up for the unconventional testing device is illustrated. The special appliance exhibits an opening at the bottom support of the test specimen. Hence, cavitation can be observed during testing by filming through the opening. Since a transparent structural silicone is bonded to transparent glass, no special issues occurred to determine qualitatively the cavitation effect during testing. Due to obstruction of lateral contraction of the adhesive, a hydrostatic stress state is present. The test specimen, which is composed of a point fixing, a glass pane and structural silicon, is also illustrated.

To numerically model the cavitation effect in rubber-like materials, a novel volumetric hyperelastic material model was implemented in ANSYS FE Code. To determine the unknown material parameters, the inverse Finite Element Method (iFEM) was used. Initially, material parameters were scattered stochastically and a comparison between experiments and numerical calculations was carried out. After limiting the material parameters, a direct optimization algorithm was used to obtain optimized parameters. The results can be seen in Fig. 3. optiSlang was used for the inverse calculation of the material parameters.

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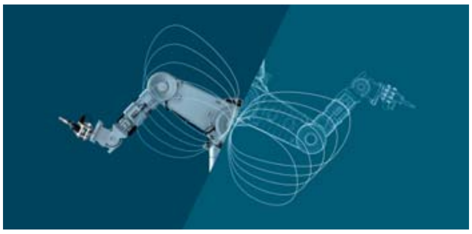
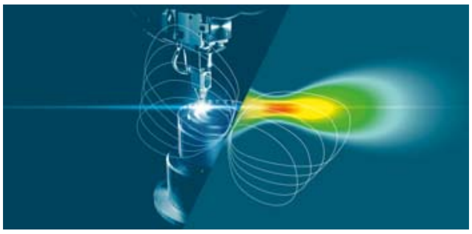
VIPO
SIMULATION DRIVEN
PRODUCT AND PROCESS OPTIMIZATION

Forschung

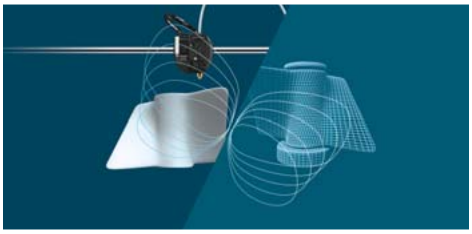
VIRTUELLE PRODUKT- UND PROZESSOPTIMIERUNG FÜR DIGITALE VERFAHREN UND METHODEN



VIPO-Plattform
Die Technologie-Plattform „Virtuelle Produkt- und Prozessentwicklung und -optimierung" (VIPO) stellt Dienstleistungen und Software zur virtuellen Produkt- und Prozessoptimierung sowie zur prädiktiven Wartung entlang der Wertschöpfungskette des Produktlebenszyklus bereit. Im Mittelpunkt stehen dabei Feldzusammenhangsmodelle (FZM) die als Grundlage für Digitale Zwillinge dienen.



Verbundprojekt 1: Produktoptimierung – Auslegung und Optimierung optischer Geräte
Kunden aus der Photonik-Branche können die simulationsgestützte Produkt- und Prozessoptimierung unter Verwendung kalibrierter und parametrischer Simulationsmodelle über mehrere physikalische Domänen nutzen.



Verbundprojekt 2: Prozessoptimierung – Additive Fertigung auslegungsrelevanter Bauteile in Kunststoff
Um die Produktqualität von additiv gefertigten Bauteilen mittels Simulationsverfahren vorhersagen und optimieren zu können, werden hier performante Materialmodellierung und Prozesssimulation für Feldmetamodelle (FDM) von Kunststoffbauteilen entwickelt.

Verbundprojekt 3: Digitaler Zwilling – Optimierung und prädiktive Wartung rotierender Maschinen
In diesem Verbundprojekt werden Feldzusammenhangsmodelle entwickelt, welche die Veränderung von Feldgrößen vorausberechnen können. Diese FZM werden in Digitalen Zwillinge integriert und liefern nahezu in Echtzeit Informationen über die aktuelle Lebensdauer aller relevanten Bauteile.

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WACHSTUMSKERNE UNTERNEHMEN REGION Die BMBF-Innovationsinitiative Neue Länder

VNiVERSiDAD
Ð SALAMANCA

Mechanical Engineering

DESINGNING OF COMPOSITE PRESSURE VESSELS USING ABAQUS AND OPTISLANG

Fig. 1: a-Filament winding technique b-COPV / c-Digital image correlation for Random Fields / d-Fire extinguisher

Filament winding (Fig. 1) methodology has become a very popular technique for designing extremely high stiffness-to-weight structures in a wide variety of industries such as aerospace or automotive. Applications on these fields include rocket propellant tanks, rocket motor casings or high-pressure fuel storage tanks for hydrogen powered automobiles. A new application, which is being studied at the University of Salamanca, is the application of this technology to make fire extinguishers (Fig 1.)

Thus, an experimental campaign has been designed, among a series of numerical studies to complement it. These numerical studies have been prepared using the finite element software ABAQUS. The typical capabilities of the commercial finite element codes are not enough to take into account the continual variation of the fiber orientation and its effects on strains and stresses, which vary from point to point, especially in the spherical parts of the vessels. Because of this, ABAQUS includes a special plug-in, the wound composite modeler (WCM), which is capable of dealing with this kind of problems. Fig. 2 shows an axisymmetric model created with this plug-in in this study.

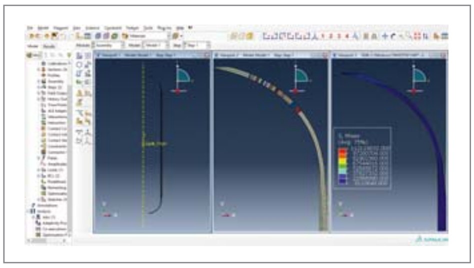

Fig. 2: WCM results

To complete the high capabilities of these ABAQUS models, they have been combined with numerous tools and features including optiSLang, which can perform sensitivity analysis, optimizations, as welll as reliability and robust design evaluations. With optiSLang it is possible to calculate the best options (number and thickness of the layers, effect of the fiber angles, the elastic moduli of the fibers ...) to design a very efficient vessel with the best strength properties and the minimal amount of material. Fig. 3 shows a sensitivity analysis conducted with optiSLang.

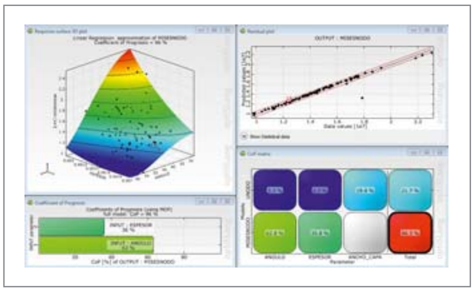

Fig. 3: Sensitive analysis and postprocessing, Fiber orientation and thickness optimization using optiSLang

For future projects we will go a step further by implementing the Random Fields Theory (Fig. 1), with data obtained from Digital Image Correlation by using Dynardo's Statistics on Structures to generate more realistic models.

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