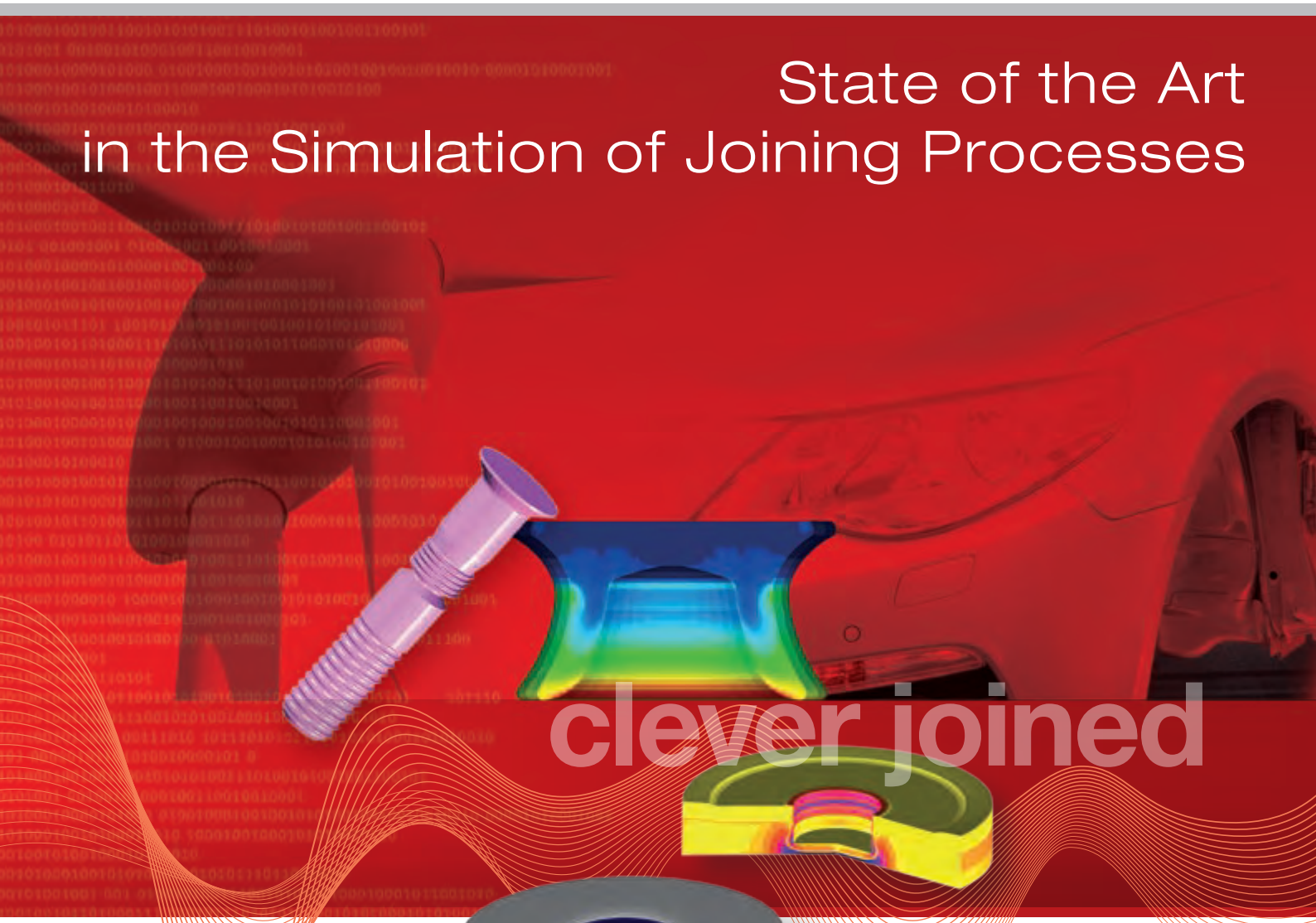
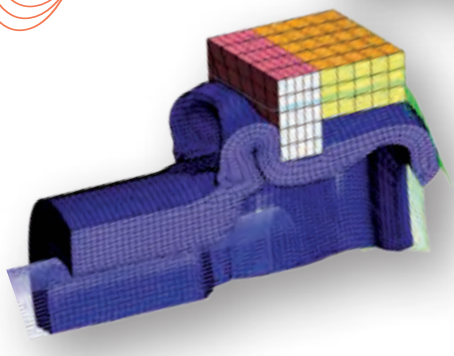
State of the Art in the Simulation of Joining Processes



clever joined



Semi-tubular riveting

Self-piercing riveting

Blind riveting

Bolt firing

Clinching

Hybrid application with glue

CFRP Implementation

High Speed Effects

Lockbolts

Crimping

Caulking

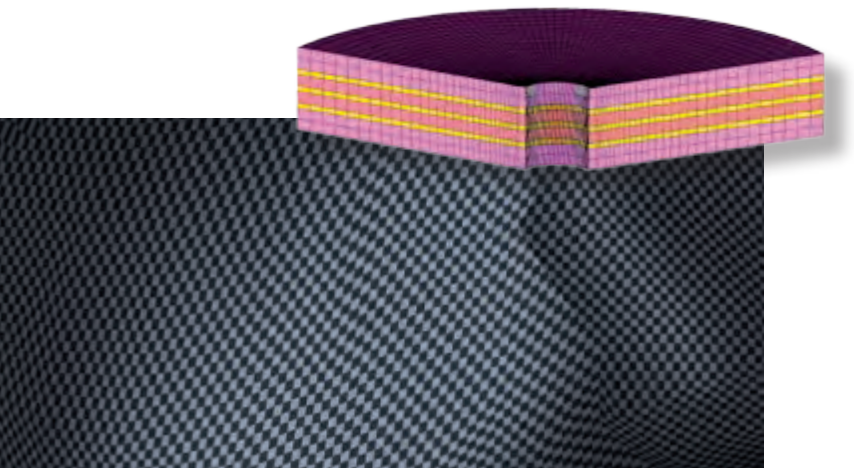
simufact
Simulating Manufacturing
MSC Software Company

Joining processes on the rise

Joining processes – that is welding, adhesive bonding and mechanical joining – are deployed in constructions and components of all sizes. Across virtually all areas of machinery and plant engineering, the automotive, aerospace and shipbuilding industry as well as in process and electrical engineering, questions of joining technology are highly relevant.

Because of the megatrend towards lightweight construction joining technology has developed several innovations. To fully exploit the potential of lightweight construction in order to more efficiently design components, industry – first and foremost the automotive and aeronautic industry – increases the use of synthetics (including CFRP), aluminum, ultra high-strength steels and foams. The challenge to join different materials safely to so-called multi-material modules demands new and efficient joining processes. To that end, there currently is intensive research in developing new or optimized joining methods.

In this process of development software-aided simulation technology can make an essential contribution: Recent simulation applications such as Simufact.forming and Simufact.welding are designed to provide realistic and significant results. The use of software reduces the development time and helps to identify potential shortcomings at an early stage. Modeling and subsequently simulating joining processes allows the targeted development of process parameters to achieve specific component properties. This is based on the prerequisite that processes and sub-processes are understood and parameters, processing conditions and product properties can be correlated.



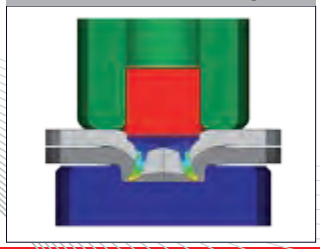
Numerical Solutions For The Mechanical Joining Technology

Indirect Joining

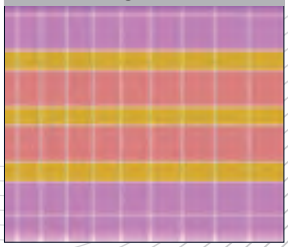
Indirect joining makes use of additional joining elements that allow joining different materials. Depending on sphere of use there is a wide range of technologies, such as blind or punch rivet processes that realize different forms of mechanical joining of material. Also coupled applications with adhesive are gaining in importance and need an intensive consideration in process design.

Blind riveting

Semi-tubular riveting



Modeling with CFRP

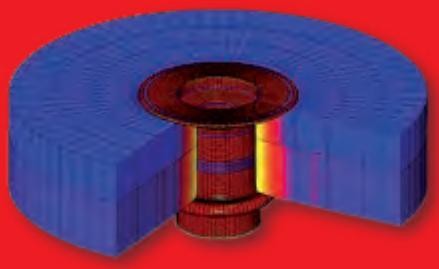


Our competence:

- Numerical simulation from rivet production and joining process through to failure analysis
- Integration of CFRP-materials, with that individual fiber layers modeled according their properties
- Multi-point considerations to analyze material behavior between two joints
- Examination of mass inertia effects
- Consideration of adhesive behavior in hybrid usage of mechanical joining processes

Your advantage:

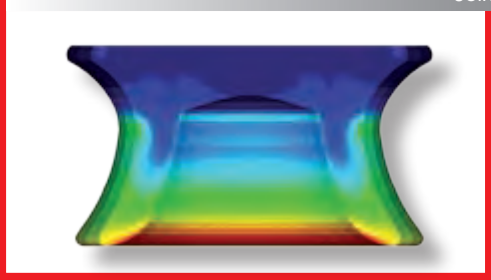
- *Efficient rivet design according latest trends in material*
- *Calculation of processes with high-speed effects*
- *Visualization of adhesive behavior in joining*
- *Reliable forecast of forces for joining processes and failure case*



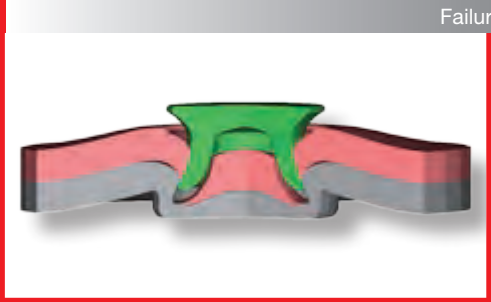
Process simulation Semi-tubular riveting

Rivet production

Joining process

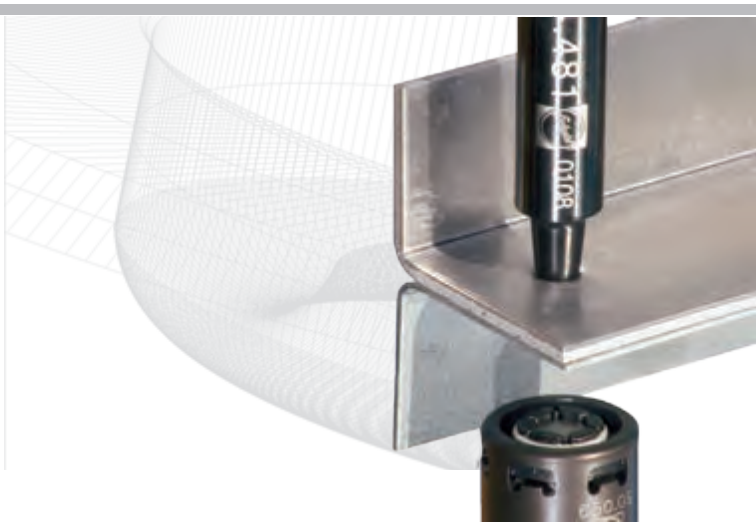


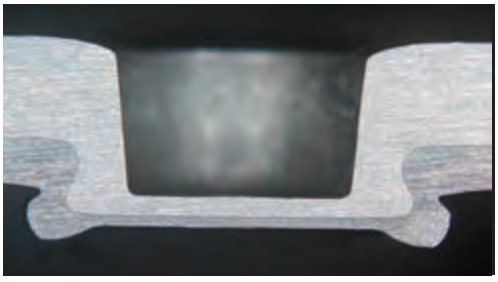
Failure prediction



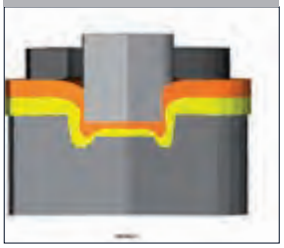
Direct joining

Direct joining, such as clinching, means mechanical joining by the plastic deformation of single components only. This increases the relevance of material flow for the joining result. Hence, a decisive factor for this process group is precise process design according to the respective material combination.





Simulation model



Tool optimization

Wobble kinematics

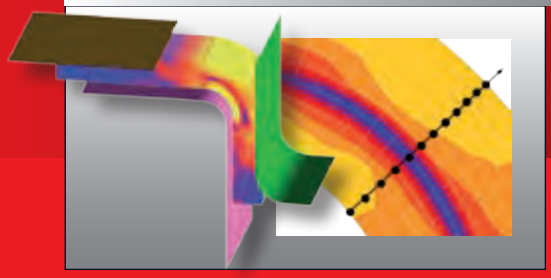
Our competence:

- Numerical simulation of mechanical joining technologies
- Implementation of mechanical-physical material properties, e.g. steel, aluminum, synthetics
- Flexible integration of tool kinematics (e.g. wobble movements of the punch)
- Technology optimization or development
- Visualization of the whole 3D-stress condition
- Realistic macroscopic abstraction of boundary layer behavior for form- and force closure on the microscopic range

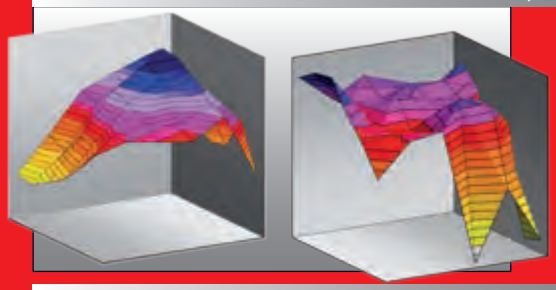
Your advantage:

- *Analysis of parameters influencing the process and their multifactorial relations*
- *Visualization of material flow during joining*
- *Efficient adjustment of tool geometry in new material combinations*
- *Design of clinch connections considering the relation of interlocking, neck- and bottom thickness*
- *Simulation of mechanical microform connections*

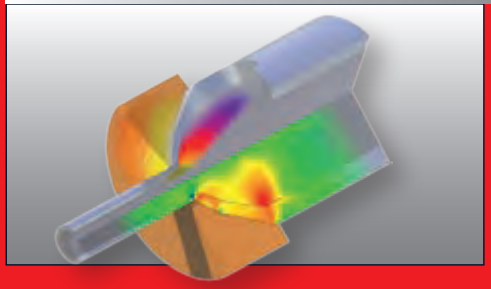
Crimping



Optimization



Microform connection



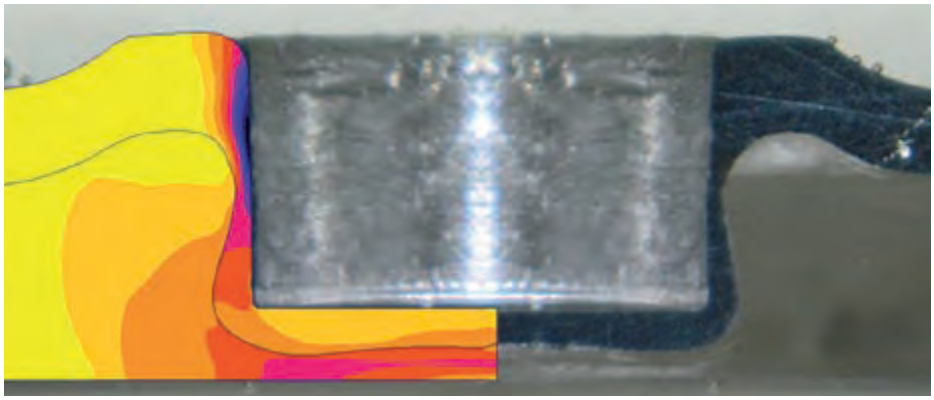
CASE STUDY

CHALLENGE:
Development of a clinch connection with a plane surface on the die side

SOLUTION:
Systematic process development using numerical simulations

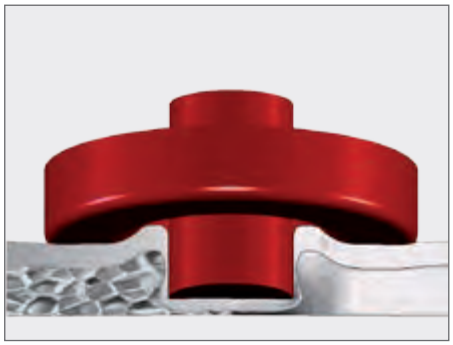
USED PRODUCTS:
Simufact.forming

CUSTOMER:
Eckold GmbH & Co. KG

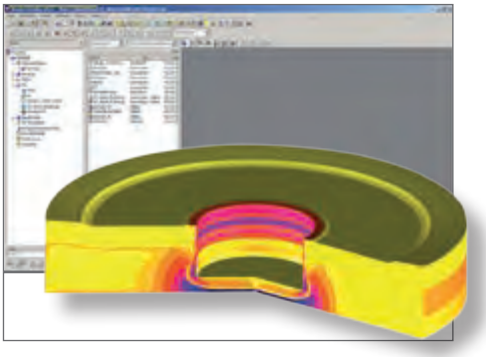


Innovative joining process developed with Simufact.forming

Joining specialist Eckold realizes flat-clinch technology based on FE simulation



Objectives



Simulation

Results

Using Simufact.forming for process simulation the joining specialist Eckold GmbH & Co. KG and the Chair of Virtual Production Engineering, Chemnitz University of Technology, developed an innovative flat-clinch technology. The aim of the development project was to produce a form of connection that joins organic and/or inorganic material mechanically in a single-staged process to a mechanical compound with a plane surface on the die side.

The development of the flat-clinch-process is primarily based on the finite element method. In a first step, it was necessary to determine the particular flow properties of the test materials. Having deposited this information and modeled each tool and processing step, targeted simulation calculation and numerical material flow analyses were realizable. Based on this, the multifactorial relations of relevant factors were analyzed to derive procedural principles.

The newly acquired insights were used for numerical shape optimization of tool components. The individual tool components were integrated into the machinery concept and implemented in the universal C-shaped stand machine DFG 500/150E of Eckold GmbH & Co. KG, which was specifically adapted for the flat-clinch technology. The experimental validation of the numerical results proved that metal components, metal and synthetic components as well as synthetic and cardboard components can be clinched flatly.

„Using flat-clinch joint we were able to develop a stabile form- and force closure connection with one-sided flatness that is deployable in the viewable area or as functional surface. For us this has opened up new fields of application in mechanical joining technology. This process is also suitable for joining dissimilar materials, e.g. synthetics with metal. Therefore is flat clinching an excellent opportunity to ensure multi-material design with a short and effective process chain and to further intensify intelligent lightweight engineering with its trend towards material-mix."

MBE Sven Schulze,
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Chair of Virtual Production Engineering, Chemnitz University of Technology