FORMING SIMULATION, META LANGUAGE AND INPUT DECKS.

TRANSLATION OF THE META LANGUAGE FOR FORMING SIMULATION INTO AN INPUT DECK FOR A FEM SOLVER.

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BMW GROUP

THE NEXT 100 YEARS

BMW · MINI · Rolls-Royce Motor Cars Limited

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INTRODUCTION.
BMW GROUP PRODUCTION NETWORK.

Oxford MINI

Hams Hall Engines

Goodwood Rolls-Royce

Swindon Components

Moses Lake
Components

Spartanburg
BMW X3, X4, X5, X6, incl. M variants

San Luis Potosí
Start of Production 2019

Born

Kaliningrad

Steyr Engines

Graz

Kairo

Chennai

Shenyang
– **Tiexi** BMW 2 Series AT, 3 Series, 3 Series long version, X1 long version, ZINORO M13
– **Dadong** BMW 5 Series long version
– **Engine Plant**

Rayong

Kulim

Jakarta

Manaus
BMW Motorcycles

Araquari
BMW 1 Series, 3 Series, X1, X3, X4

Rosslyn
BMW 3 Series

Berlin BMW Motorcycles, Maxi-Scooters, Components

Eisenach
Components

Wackersdorf
Components

Landshut
Components
Electric Engines

Leipzig BMW 1 Series, 2 Series, 2 Series AT, M2, i3, i8

Regensburg BMW 1 Series, 2 Series GT, 3 Series, 4 Series Conv., M3, M4 Conv., X1

Dingolfing BMW 3 Series, 4 Series, 5 Series, 6 Series, 7 Series, M5, M6, Electric Engines, Components

Munich BMW 3 Series, 4 Series Coupé, M4, Coupé, Engines

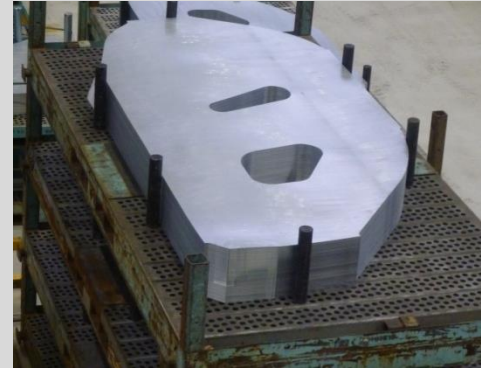|		
■ Vehicle production plant	■ Assembly plants	▲ Engines / Components
■ Joint ventures	■ Contract production	■ Motorcycle plants

INTRODUCTION.
PRESS SHOP.

Raw material

Coil-cut

Press line

Forming tool
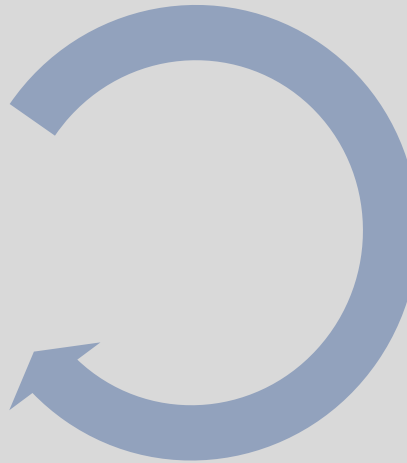
INTRODUCTION.
PRESS SHOP.
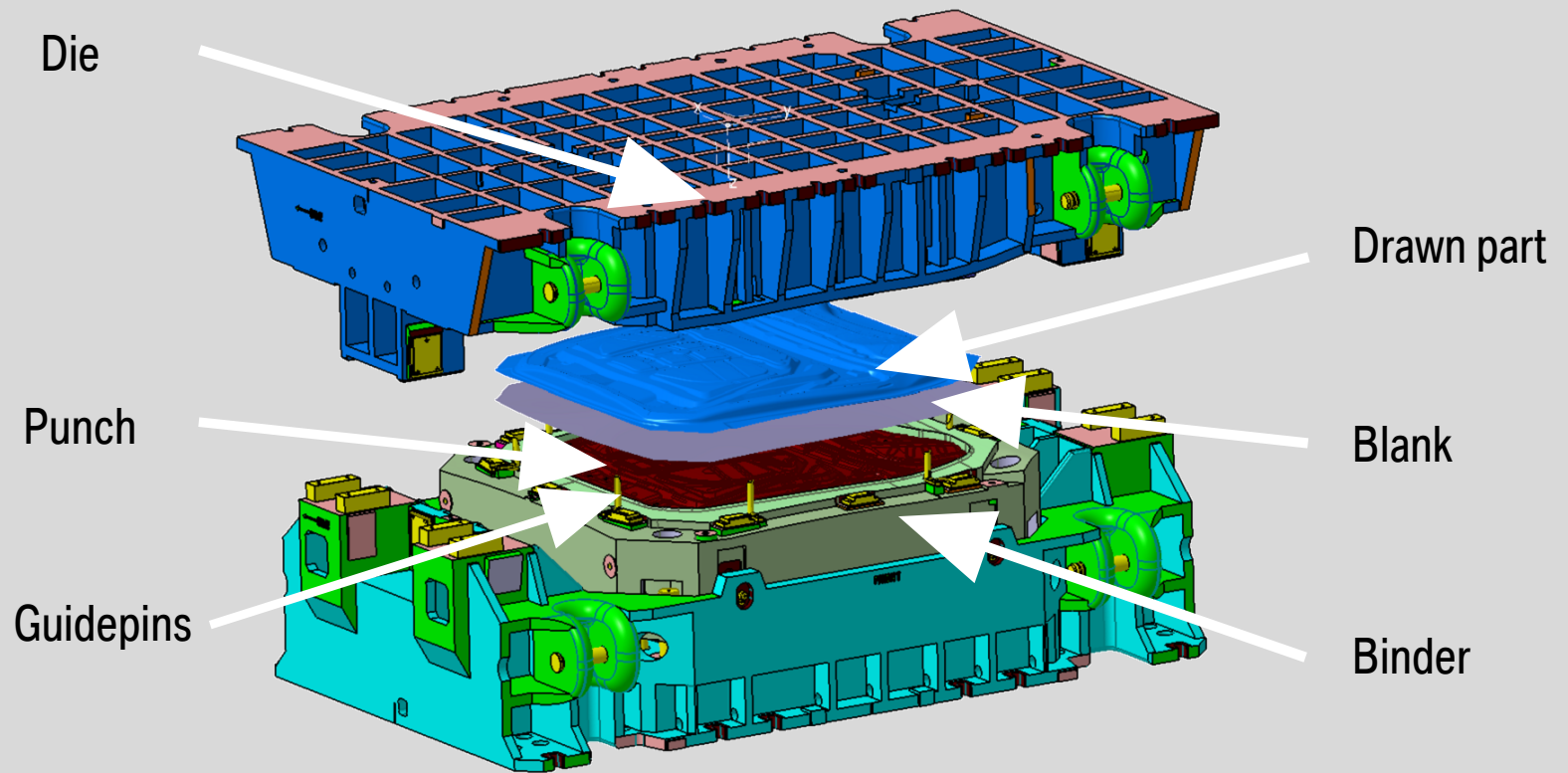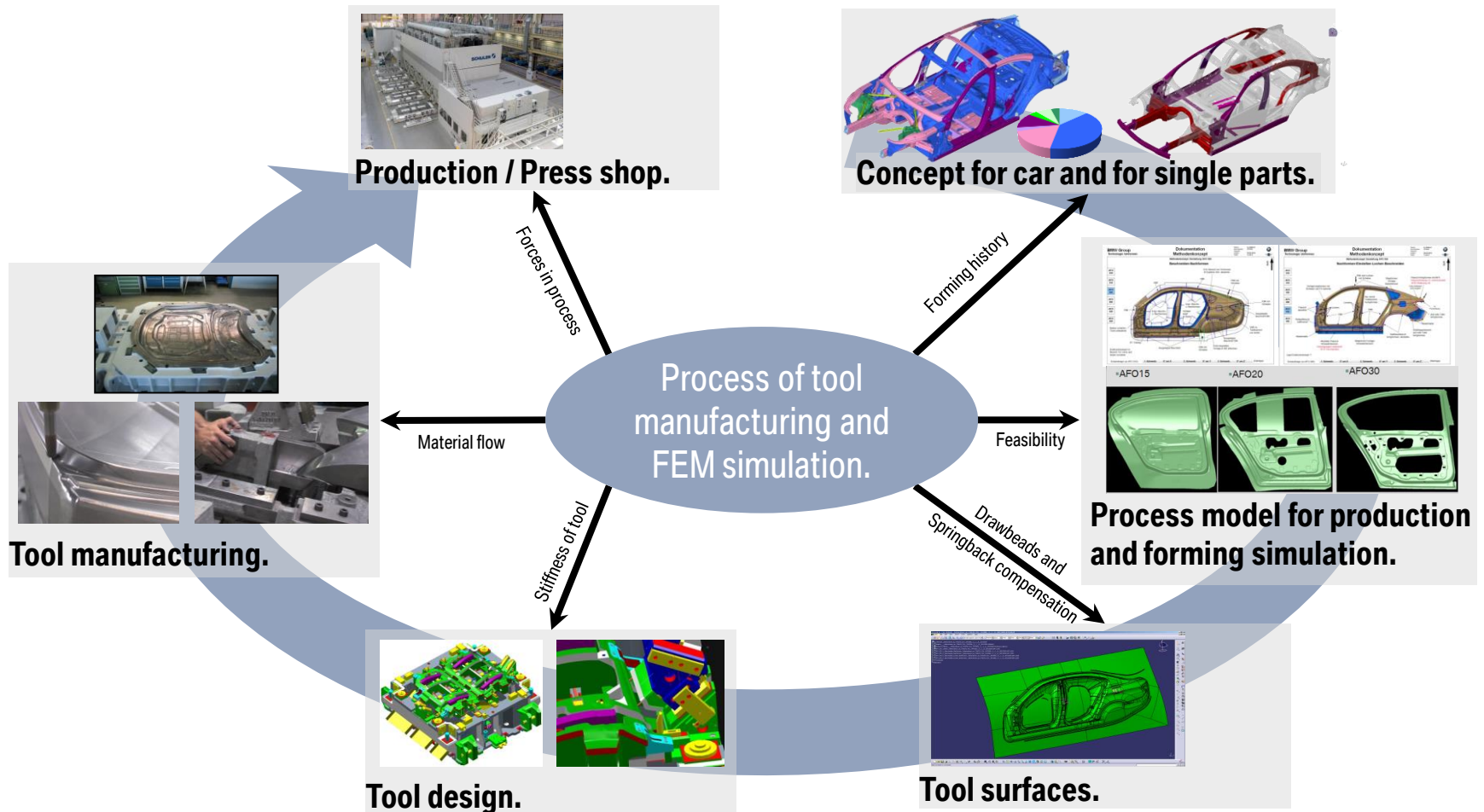
Exemplary setup of a forming tool of a hood-inner.

Die

Drawn part

Punch

Blank

Guidepins

Binder

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FORMING SIMULATION AT BMW – STATE OF THE ART.
SIMULATION IN THE TOOL DEVELOPMENT PROCESS.

Production / Press shop.

Concept for car and for single parts.

Process of tool manufacturing and FEM simulation.

Forces in process

Forming history

Material flow

Feasibility

Stiffness of tool

Drawbeads and Springback compensation

Tool manufacturing.

Process model for production and forming simulation.

Tool design.

Tool surfaces.

FORMING SIMULATION AT BMW – STATE OF THE ART. SOFTWARE CONCEPT.

– Modular setup of the processes.

Forming concept.

Geometry.　Material.　Process.

Preprocessing.

Solving.

Postprocessing.

No. ← Successful forming process?

↓ Yes.

Validated forming process.

Geometry.　Material.　Process.

Modification of model parameters.
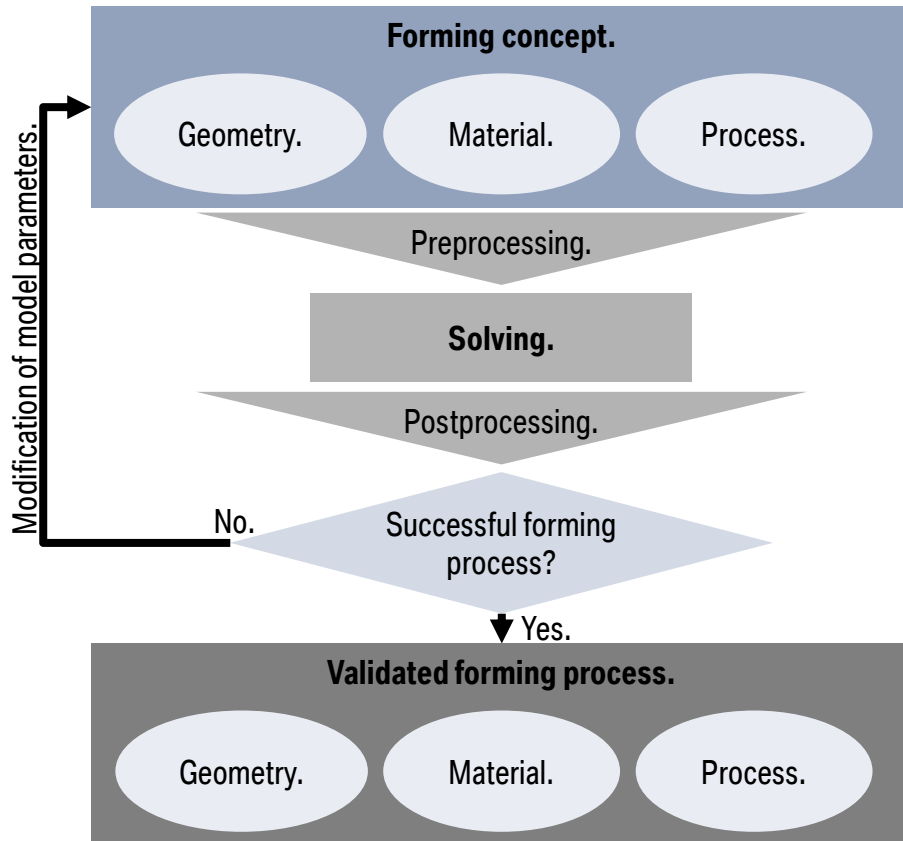
– Application of forming simulation.

Trimming

Software

Deformation of tools and press

Material data

σ_2

σ_1

Draping of CFRP

Forming Simulation

Cold forming

Press hardening

Springback compensation
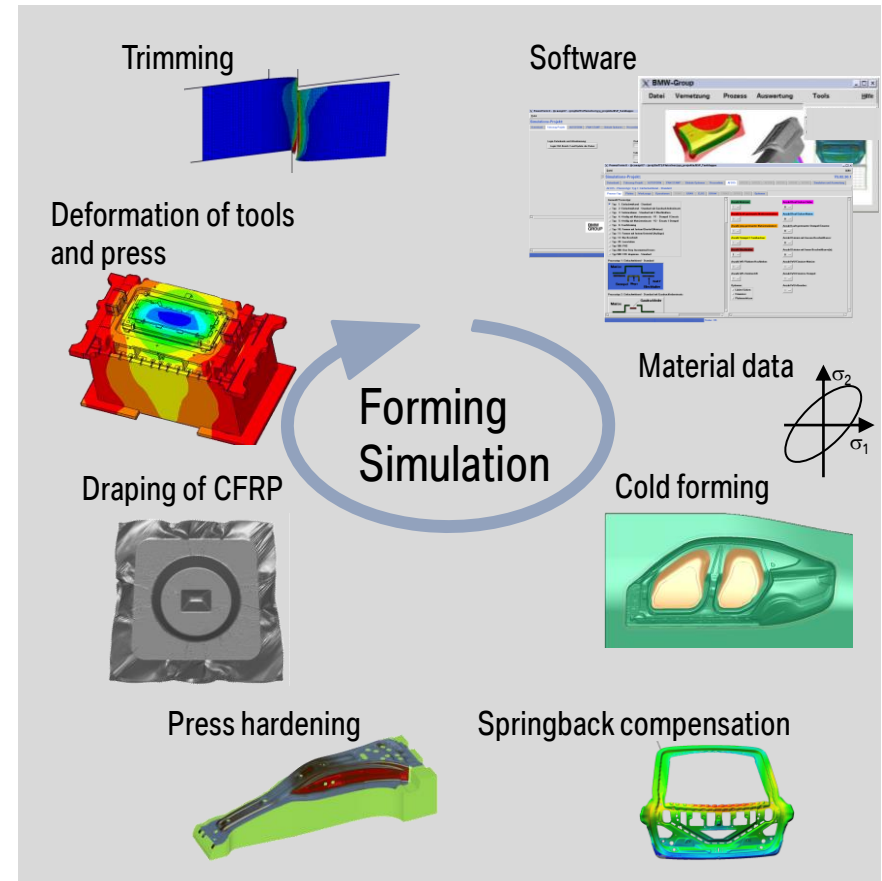
FORMING SIMULATION AT BMW – STATE OF THE ART.

The BMW meta language was implemented into a commercial version OFPL within a cooperation* with GNS** since 2010.
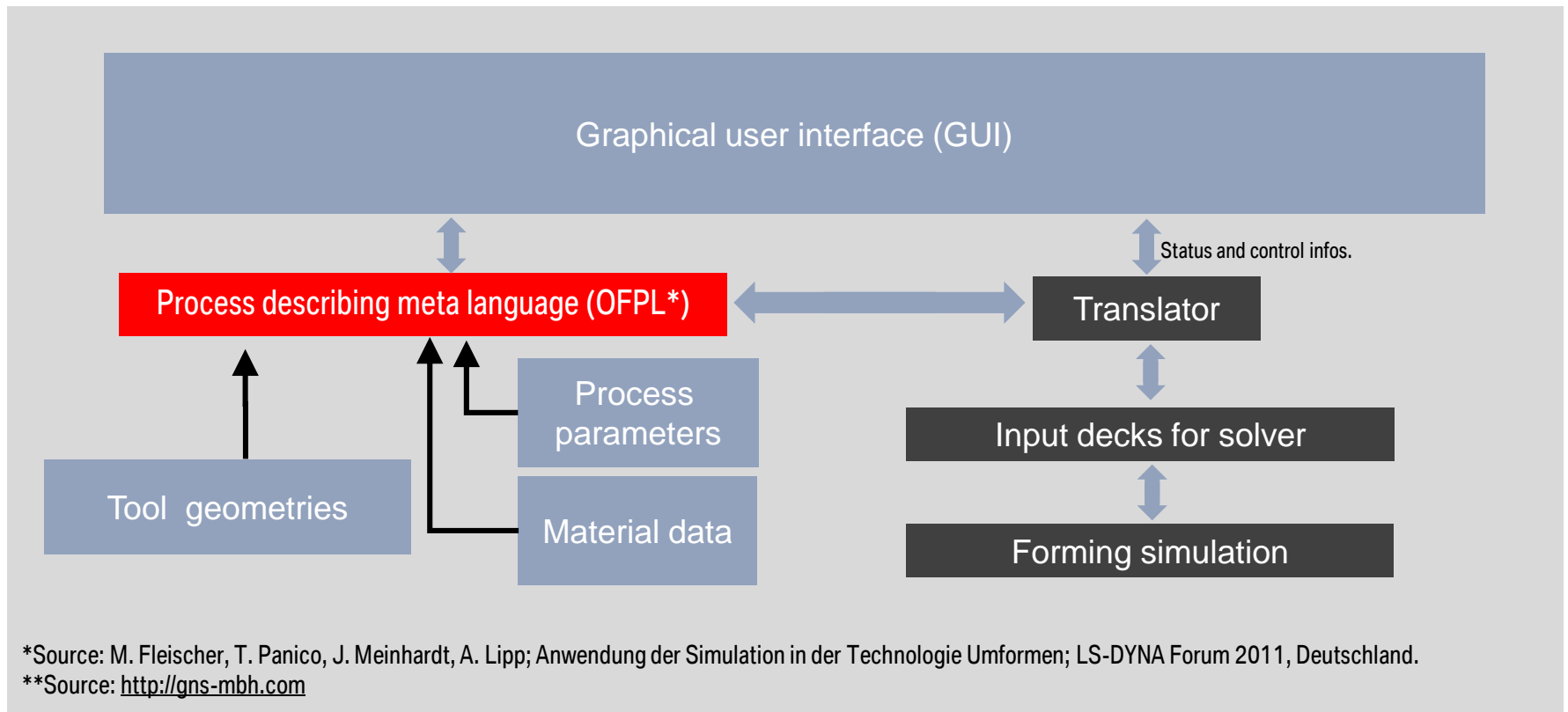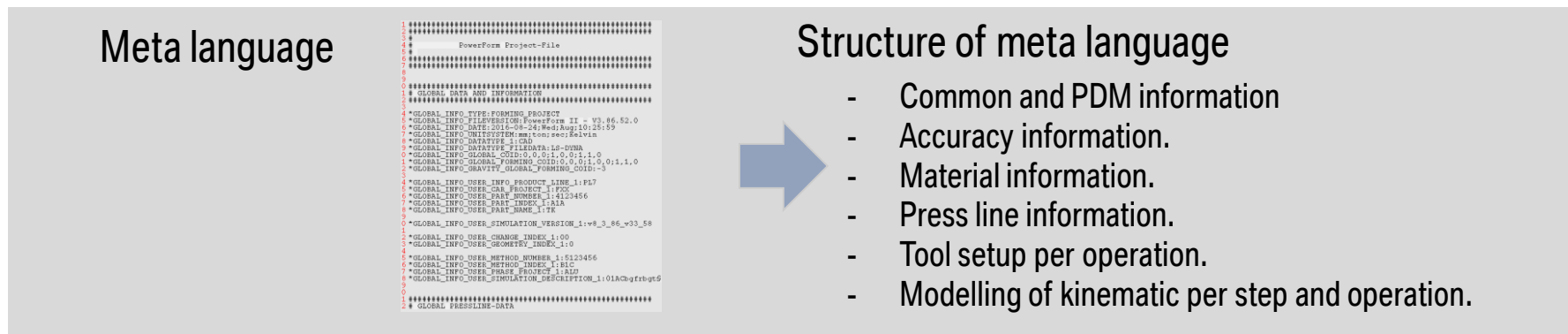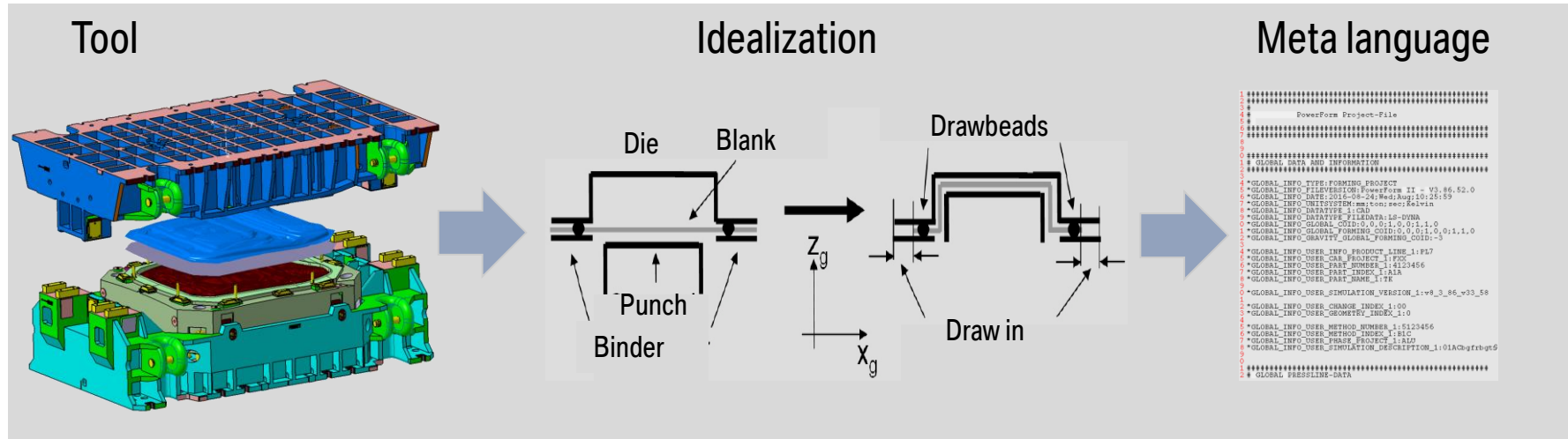

Graphical user interface (GUI)

Status and control infos.

Process describing meta language (OFPL*)

Translator

Process parameters

Input decks for solver

Tool geometries

Material data

Forming simulation

*Source: M. Fleischer, T. Panico, J. Meinhardt, A. Lipp; Anwendung der Simulation in der Technologie Umformen; LS-DYNA Forum 2011, Deutschland.
**Source: http://gns-mbh.com

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FROM THE META LANGUAGE TO THE SOLVER INPUT DECK.

From the tool to the meta language.

Tool	Idealization	Meta language

Die — Blank

Punch

Binder

Drawbeads

Draw in

Z_g

X_g

Meta language

Structure of meta language

- Common and PDM information
- Accuracy information.
- Material information.
- Press line information.
- Tool setup per operation.
- Modelling of kinematic per step and operation.

FROM THE META LANGUAGE TO THE SOLVER INPUT DECK. GENERIC MODEL.

Modelling for structure and heat transfer in the generic model.

Die

Thermal properties of blank
− Conduction, radiation and convection

Friction to thermal energy

Plasticity - 90% * to thermal energy

Blank

F_Binder

v_Punch

Friction to thermal energy

Binder

Punch

Thermal properties of tools
− Conduction in the tools (1mm Shell)
− Idealization of the heat conduction into the tool analog to a "solid" tool

Input deck for FEM solver

Structure	Fluid dynamics
Heat transfer	Electro magnetism

* Taylor, G. I. ; Quinney, H.: The latent energy remaining in a metal after cold working. In: Proceedings of the Royal Society London A Bd. 143, 1934, S. 307–326.

# FROM THE META LANGUAGE TO THE SOLVER INPUT DECK. GENERIC INPUT DECK.

Generalized setup for input decks with process and object orientation with parameters.

Main input deck

Include of:
- Process parameters

Objects
- Blank
  - Material file for blank
- Tools
  - Material file for tools

- Numerical modelling

Flow

Process parameters (structural, heat transfer, fluid, em …)

Blank mesh with tensors for stress and strain

Material file (optional: encrypted)

Tool meshes
    Die
    ….
    Binder

Numerical modelling (optional: encrypted)
    Parametrical calculations
    Modelling of structure, heat transfer, fluid, em (objects)
    Kinematical modelling (tool kinematics)
    Numerical modelling (solver)

FROM THE META LANGUAGE TO THE SOLVER INPUT DECK.
STANDARD FOR NUMBERS.

Generalized setup: Objects consist of elements with part-, node- and element-IDs.

– Standard for numbering is defined → the objects / tools can easily be exchanged.

Die (PID 100)

Blank (PID 600)

F_Binder

v_Punch

Binder (PID 300)

Punch (PID 200)
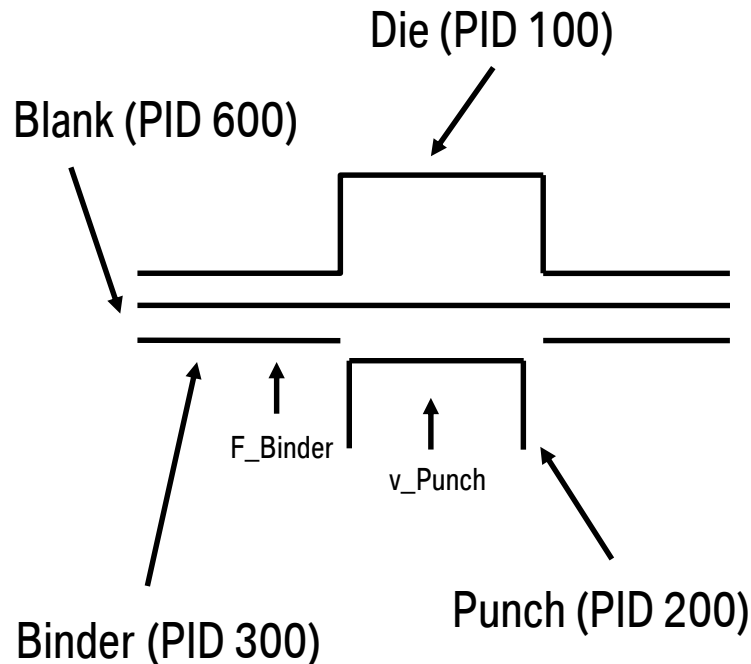
Object	Part-ID	Node- and Element-ID
Die	100 - 199	10.000.000 - 19.999.999
Punch	200 - 299	20.000.000 - 29.999.999
Binder	300 - 399	30.000.000 - 39.999.999
Line-Beads	450-499	45.000.000 - 49.999.999
Drawbeld - Notch	500-549	50.000.000 - 54.999.999
Drawbead - Rod	550-599	55.000.000 - 59.999.999
Blank	600 - 699	60.000.000 - 99.999.999

FROM THE META LANGUAGE TO THE SOLVER INPUT DECK. BENEFITS.

Benefits of a generalized and generic modelling.

- Setup is always identical →Parameter files to switch between the solvers, processes, etc.

- Translator and input decks are easier to maintain.

- Input deck structure is solver generic (ASCII input deck with parameters).

- Differences are in the kinematics, material models and boundaries.
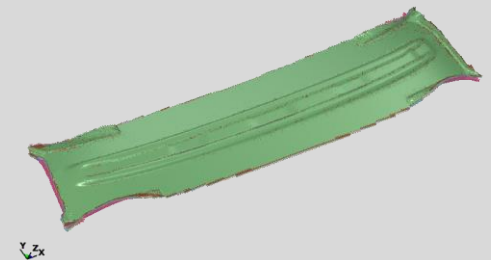
Cold forming
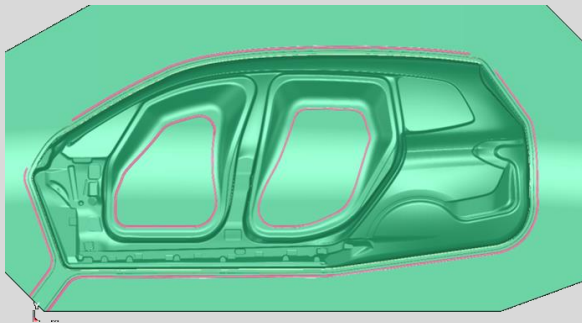
Press hardening
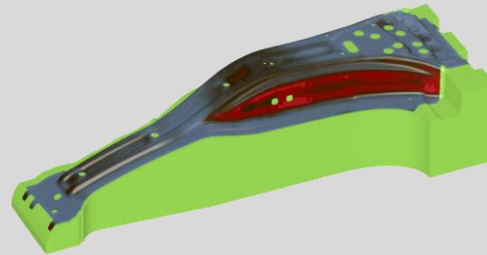
Draping of CFRP

Difference:
- Material model for blank.
- Tool modelling with solids.
- Tool kinematics.

Difference:
- Material model for stack.
- Tool kinematics.

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SUMMARY.

– Usage of meta language in processes for forming simulation processes with FE solver LS-DYNA is state of the art at BMW.

– A generalized way for translation of meta language into an input deck was implemented.

– Input decks for FEM-Solver as well as the meta language have a generic and object oriented hierarchical structure.

– A linear flow in the parameter and the numerical operations inside the input deck is created analogously to a computer program.

– Structure of input decks orients at the 4 general field problems for structure, heat transfer, fluid dynamics and electromagnetic fields.
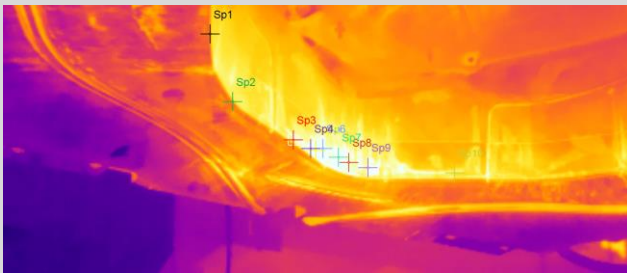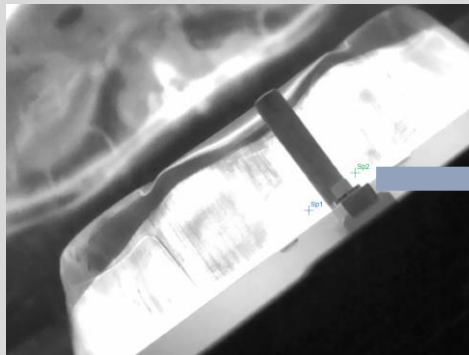
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OUTLOOK AND FUTURE CHALLENGES.

– Cold forming simulation is state of the art.

– Coupled cold forming with heat generation inside the deep drawing process is implemented.

– Example: Measurements inside the series production for validation of simulation model (wheel house).
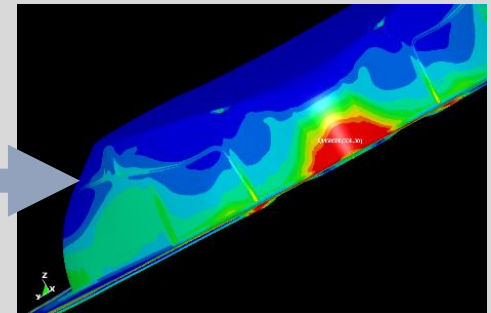
Tool

Part

Simulation of the part

OUTLOOK AND FUTURE CHALLENGES.

– With a translator module, the meta language is translated into solver input decks for standard forming simulations.

– By the general object orientation in the meta language, new disciplines now can be implemented into standard simulations and the input decks.

– CFD-Simulation.
  – Tool cooling with water.
  – Airflow around the parts during the production.

– EM-Simulation.
  – E.g.: Inductive local heating.
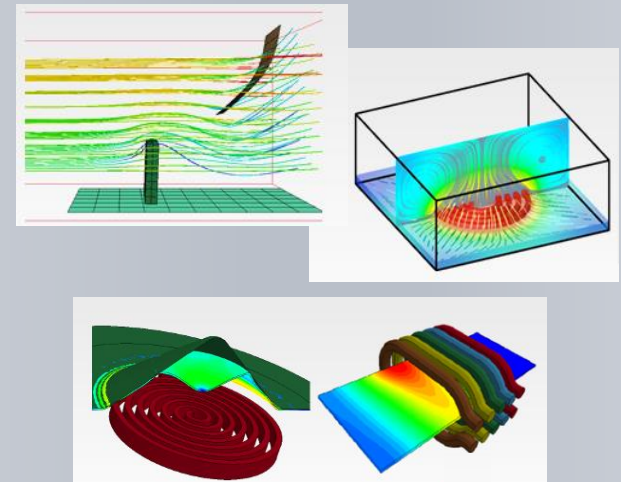
Source: www.lstc.com

THANK YOU VERY MUCH FOR YOUR ATTENTION.