OPTIMISATION USING THE DIGITAL TWIN

A plastics engineering innovation by M.TEC

M.TEC

ABOUT M.TEC

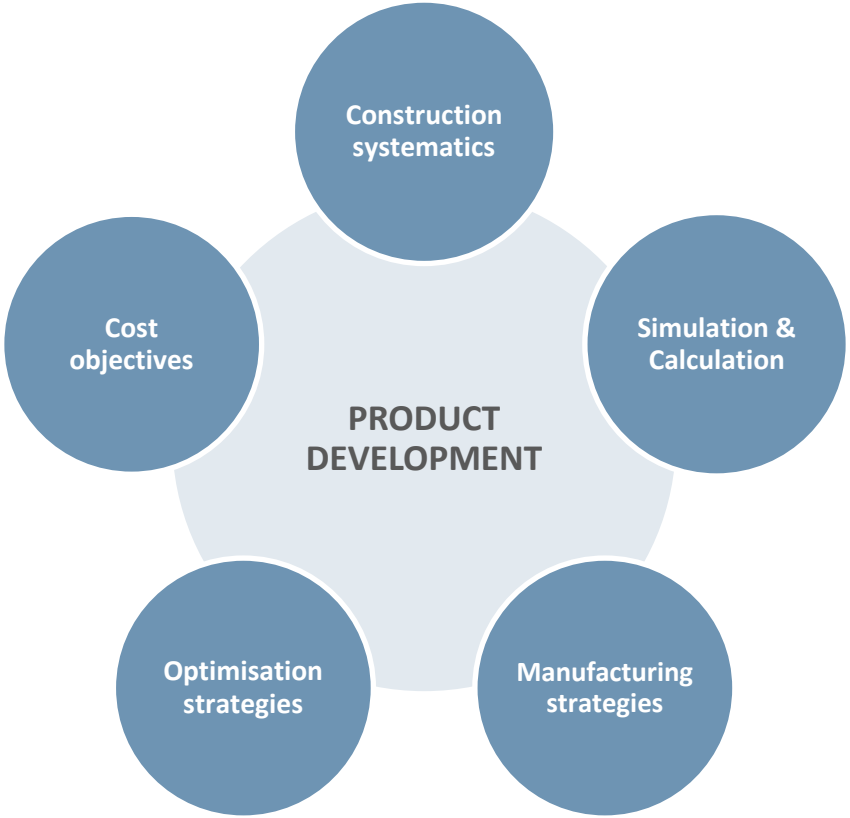
- **Design engineering service company**
  - Spin-off of the Institute of plastics processing (IKV) at RWTH Aachen University, founded in 1991
  - Member of the Feddersen Group since 06/2018
- **Development and design of technical products**
  - Holistic; from initial idea to series maturity
- **Key markets**
  - Automotive, Household appliances, Building technology, Electronic devices, Medical technology
- **Involvement in RWTH Aachen University**
  - In research projects & teaching

RWTH AACHEN UNIVERSITY

TÜV SÜD ISO 9001

ISO 9001 certified

K.D. FEDDERSEN


Construction systematics
Simulation & Calculation
Manufacturing strategies
Optimisation strategies
Cost objectives
PRODUCT DEVELOPMENT

OUR MOTIVATION

- Safety and a leading edge for our customers
- Engineering driven by passion

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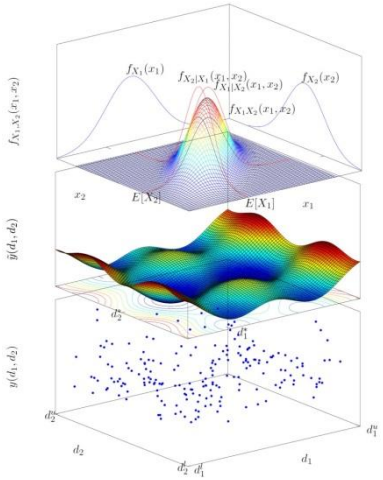
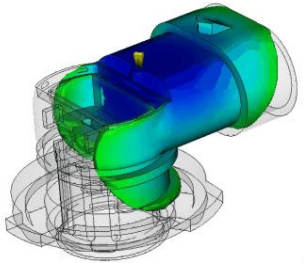
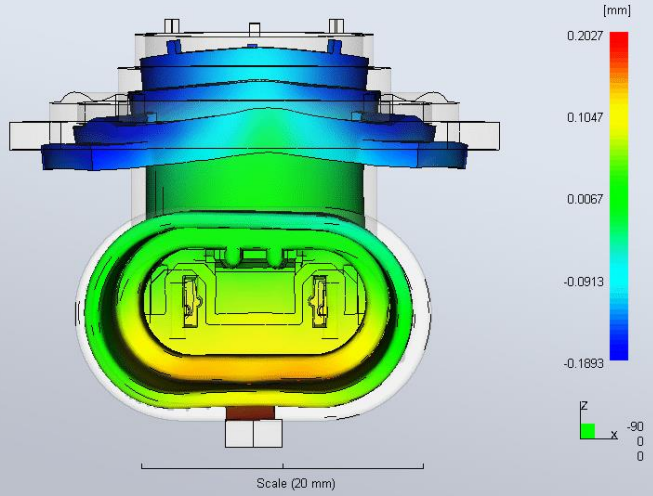


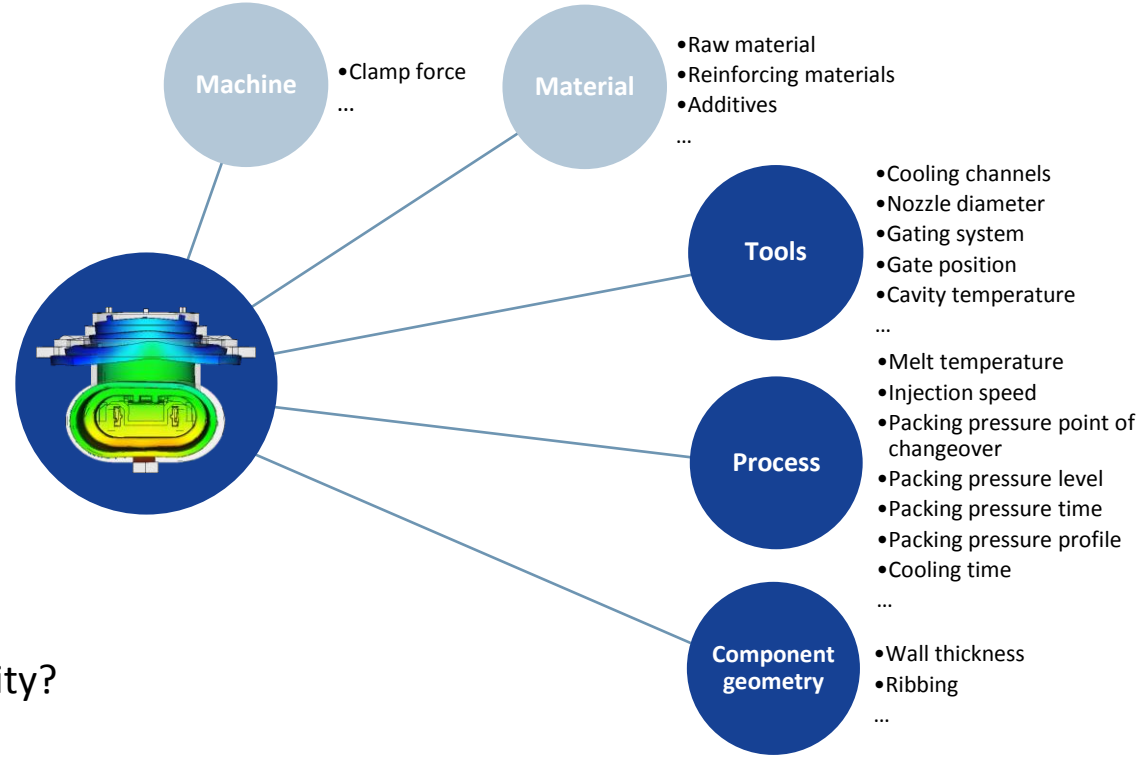
PLASTICS ENGINEERING

Optimising component warpage using the digital twin





Warpage is a function of …



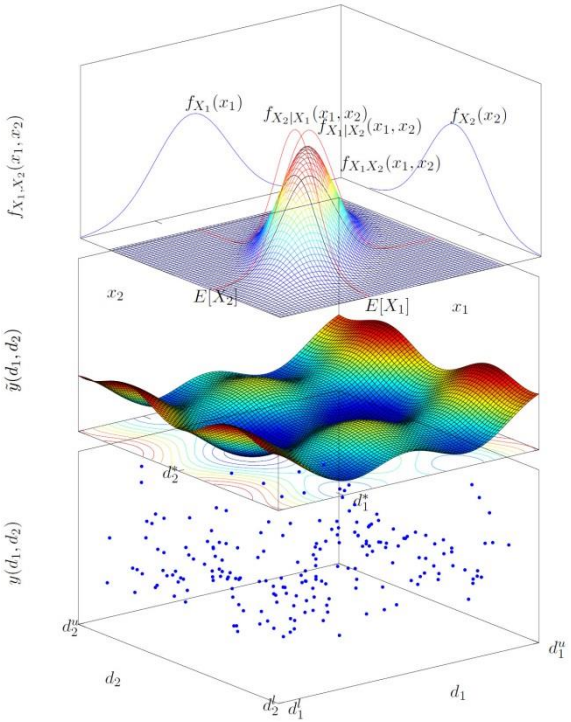
How to survey this complexity?

A mathematical image

of all physical correlations

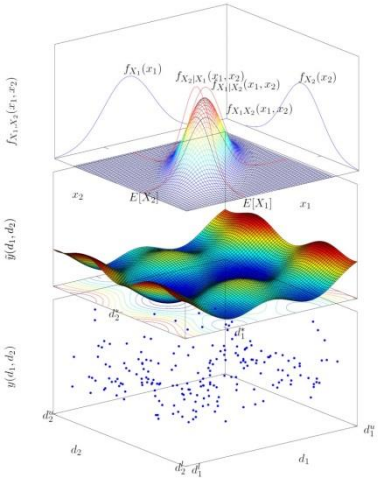
„Digital Twin“ in Wikipedia:

[…] a digital replica of physical assets, processes and systems. […] living digital simulation models that update and change as their physical counterparts change. […]

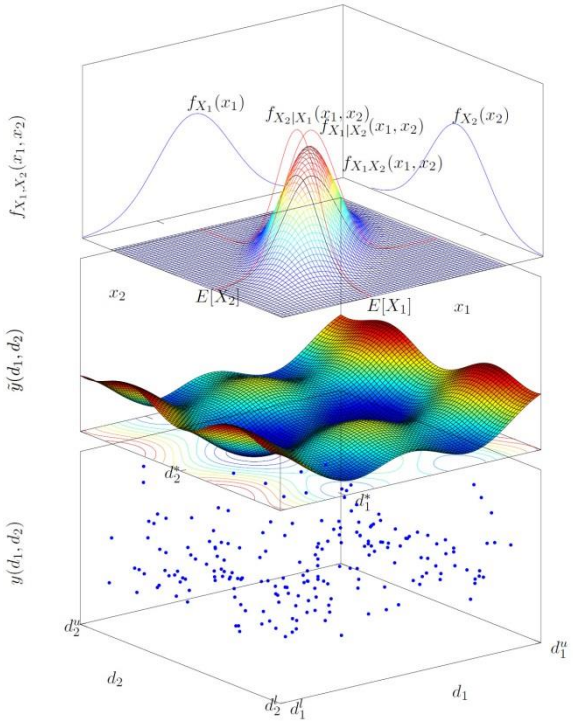


Benefits and goals

- Parameter studies real-time
- Sensitivities
- Optimisation
- Robustness



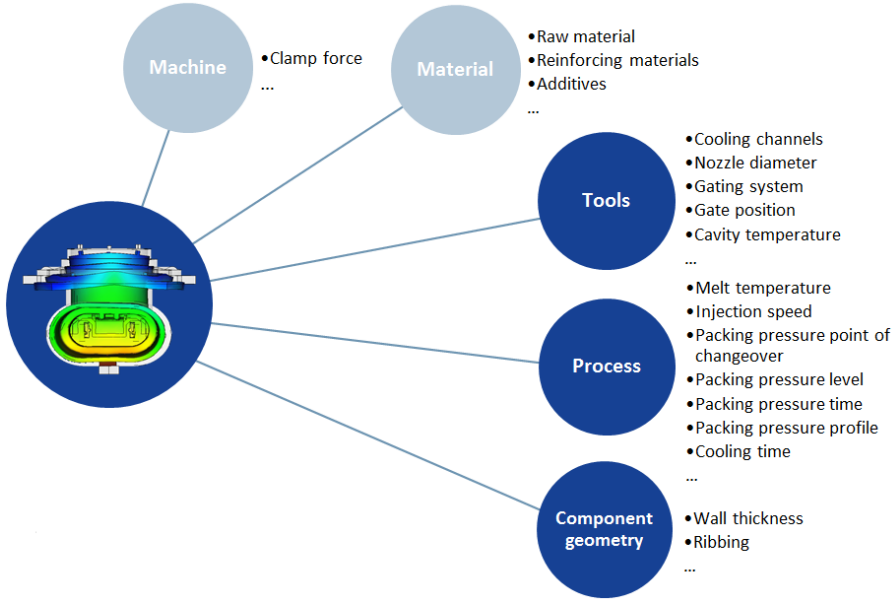
How does the digital twin evolve?



Influencing factors | Parameterisation | Experimental plan | Simulations | Function derivative

Influencing factors included by the digital twin

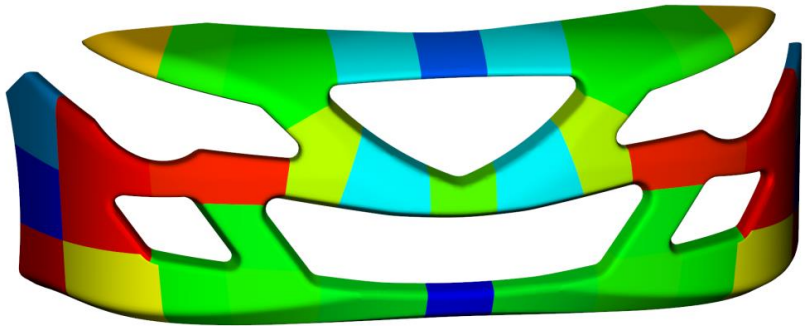
- Definition of all influencing factors taken into account
- Importance of pre-loading



Influencing factors | **Parameterisation** | Experimental plan | Simulations | Function derivative

Parameterisation and variances of the influencing variables

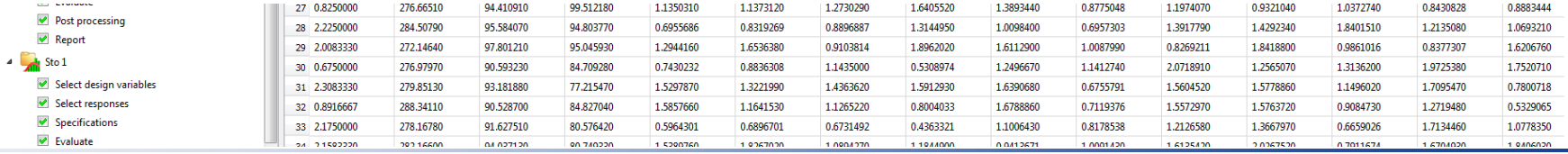
- Process parameters
- Wall thickness
- Gate positions



Influencing factors | Parameterisation | **Experimental plan** | Simulations | Function derivative

Conduction of an experimental plan

- E.g. 20 parameters varied three times results in 3.5 billion possible combinations
- Solution: Reduction of the permutation – all parameters are varied simultaneously 120 times, correlation-free and evenly spread in the parameter space (mathematical method)

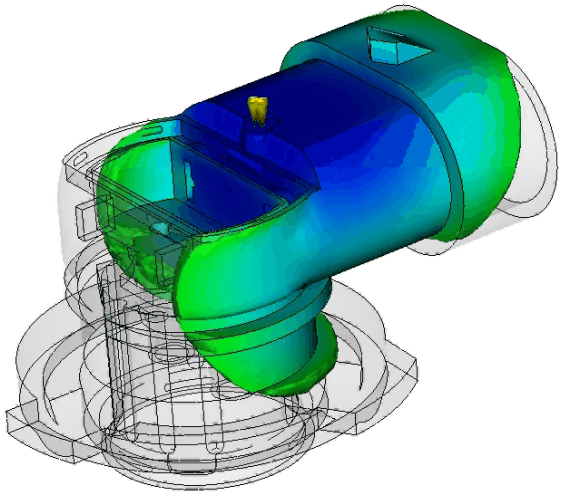


27	0.8250000	276.66510	94.410910	99.512180	1.1350310	1.1373120	1.2730290	1.6405520	1.3893440	0.8775048	1.1974070	0.9321040	1.0372740	0.8430828	0.8883444
28	2.2250000	284.50790	95.584070	94.803770	0.6955686	0.8319269	0.8896887	1.3144950	1.0098400	0.6957303	1.3917790	1.4292340	1.8401510	1.2135080	1.0693210
29	2.0083330	272.14640	97.801210	95.045930	1.2944160	1.6536380	0.9103814	1.8962020	1.6112900	1.0087990	0.8269211	1.8418800	0.9861016	0.8377307	1.6206760
30	0.6750000	276.97970	90.593230	84.709280	0.7430232	0.8836308	1.1435000	0.5308974	1.2496670	1.1412740	2.0718910	1.2565070	1.3136200	1.9725380	1.7520710
31	2.3083330	279.85130	93.181880	77.215470	1.5297870	1.3221990	1.4363620	1.5912930	1.6390680	0.6755791	1.5604520	1.5778860	1.1496020	1.7095470	0.7800718
32	0.8916667	288.34110	90.528700	84.827040	1.5857660	1.1641530	1.1265220	0.8004033	1.6788860	0.7119376	1.5572970	1.5763720	0.9084730	1.2719480	0.5329065
33	2.1750000	278.16780	91.627510	80.576420	0.5964301	0.6896701	0.6731492	0.4363321	1.1006430	0.8178538	1.2126580	1.3667970	0.6659026	1.7134460	1.0778350
34	2.1583330	282.16600	94.027120	80.740330	1.5380760	1.8267020	1.0804270	1.1844090	0.9413671	1.0091430	1.6125430	2.0267520	0.7911674	1.6704030	1.8406030

Influencing factors | Parameterisation | Experimental plan | **Simulations** | Function derivative

Moldflow analysis

- Processing the 120 sets of parameters
- Routine created by M.TEC: Control of the Moldflow preprocessor automatically executing all calculations

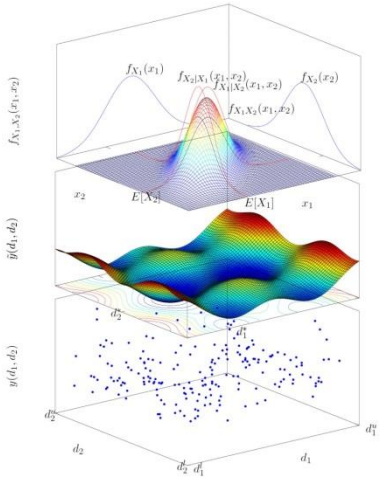


DIGITAL TWIN – WARPAGE

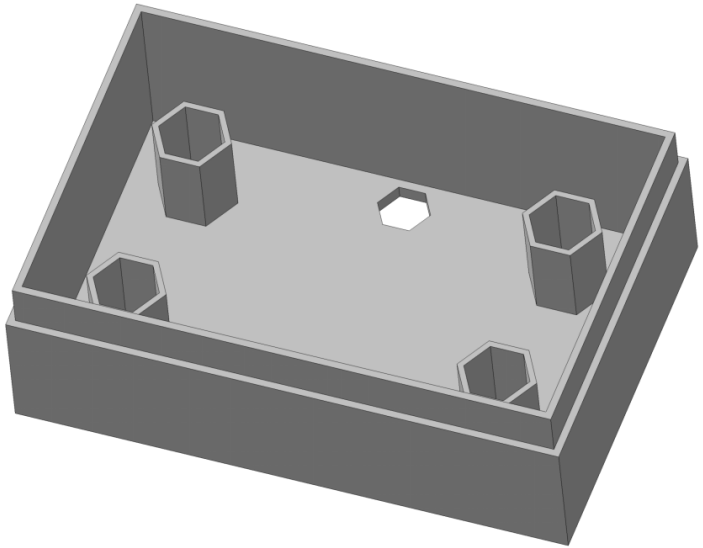
Influencing factors → Parameterisation → Experimental plan → Simulations → **Function derivative**

„Concluding“ the function – the digital twin

- Multi-level statistical method
- Combination of mathematical models

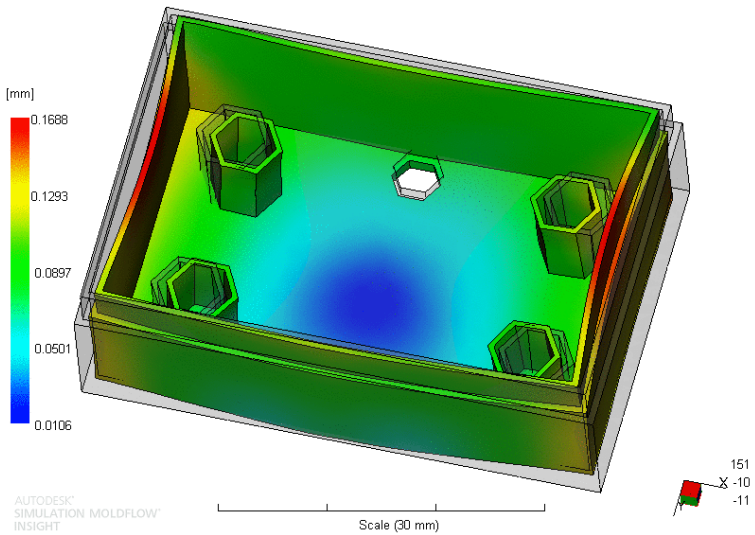


DIGITAL TWIN – WARPAGE

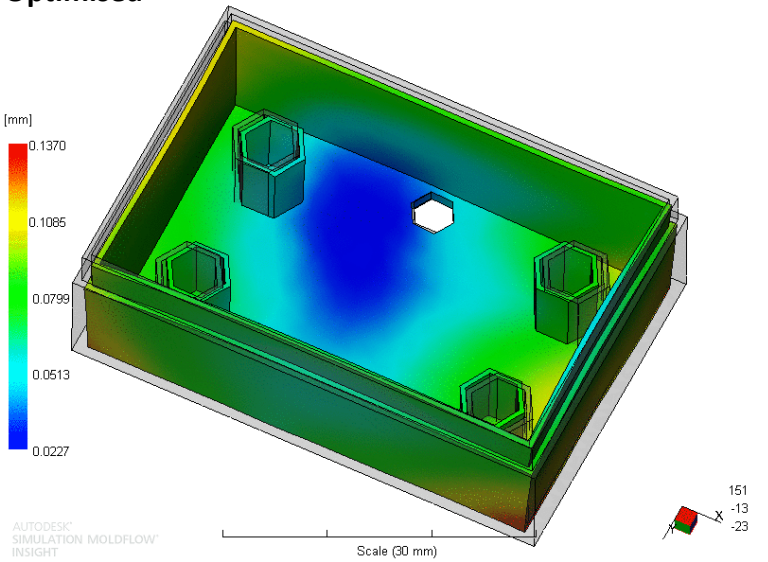


DIGITAL TWIN – WARPAGE

Original model



Optimised

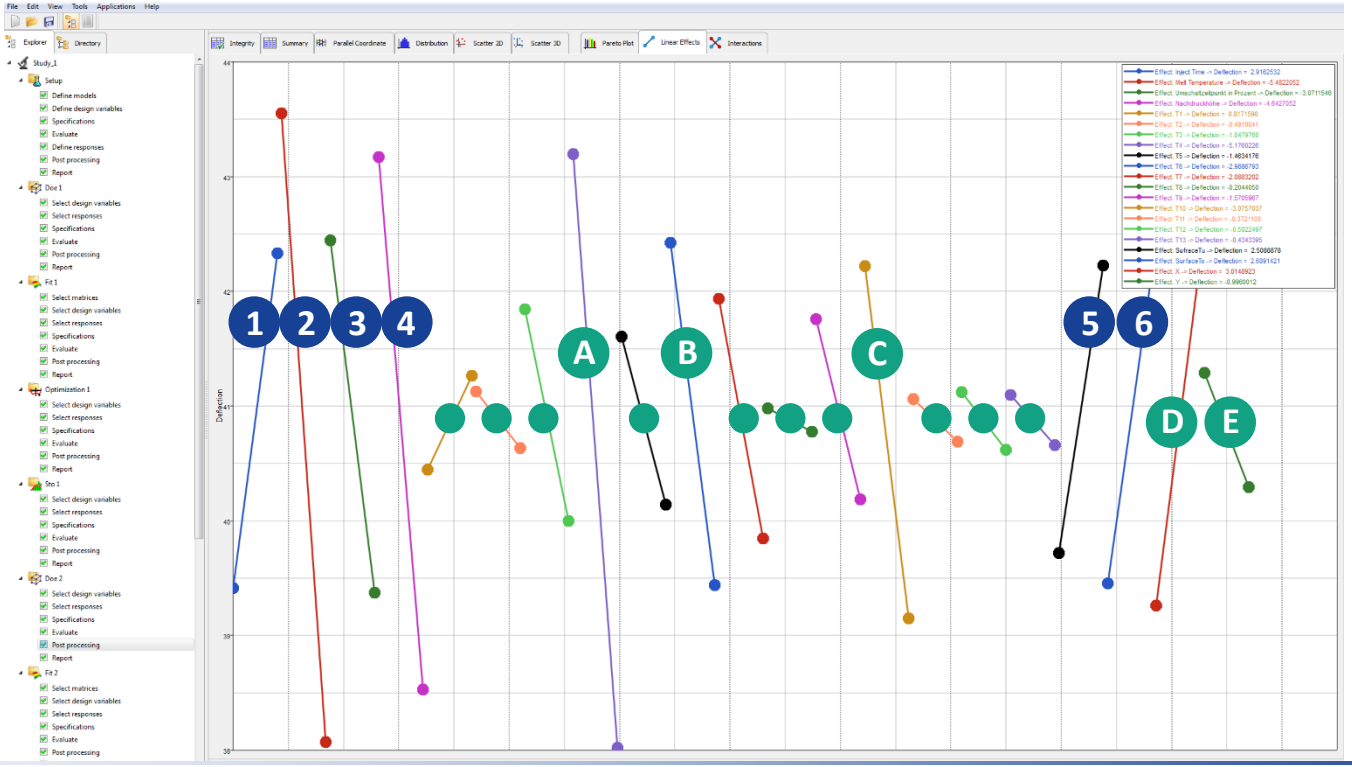


Excerpt of examined parameters:

Gate position, injection time, packing pressure, packing pressure time, mold temperature, mold wall temp.

- **Maximum warpage reduced by 20%**
- **Overall warpage much more consistent**

SENSITIVE PARAMETERS – SLIGHT VARIATION, MAJOR IMPACT



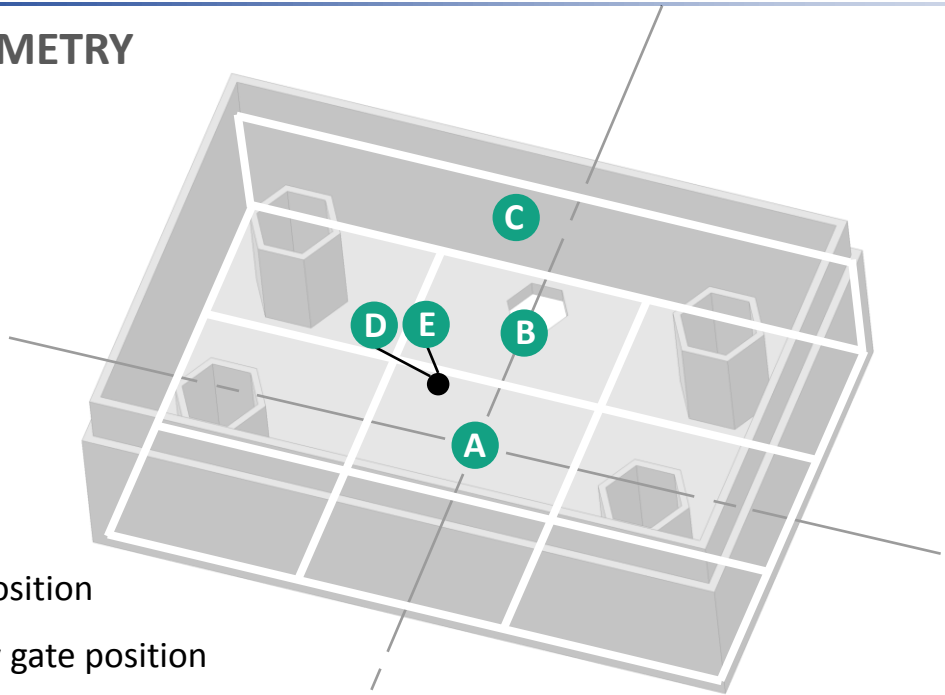
Process

1) Injection time
2) Mold temperature
3) Packing pressure point of changeover
4) Packing pressure level
5) Mold wall temperature
6) Mold wall temperature

Geometry

A) Wall thickness gate pos.
B) Wall thickness gate pos.
C) Wall thickness side face
D) X-coord. gate position
E) Y-coord. gate position

VARIATIONS IN GEOMETRY



● = Gate position

A) Wall thickness gate position

B) Wall thickness nearby gate position

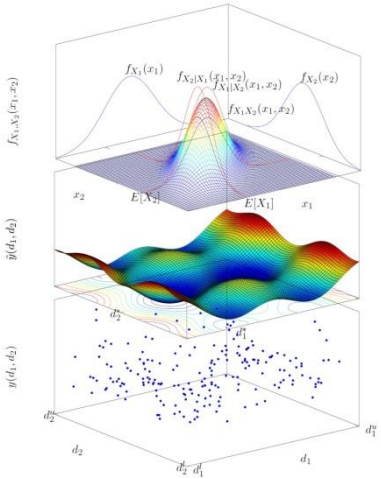
C) Wall thickness side face

D) X-coord. gate position

E) Y-coord. gate position

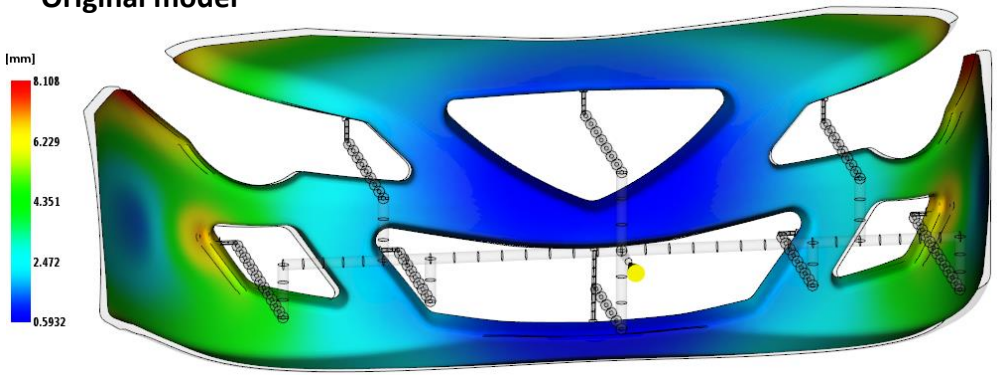
- Area divided into nine sections
- Side walls taken into account
- Variation of gate position

EXTERIOR – BUMPER

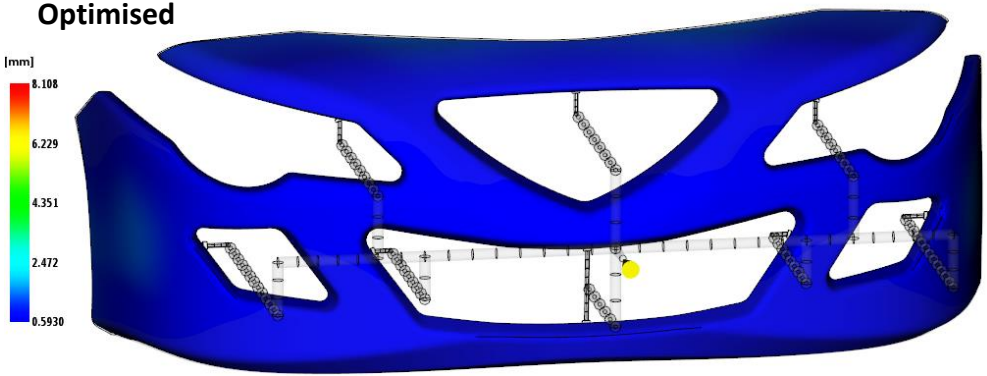


DIGITAL TWIN – WARPAGE

Original model



Optimised



Original model:

Max. warpage 8.0 mm

Improvement: 81 %

But: Packing pressure level increased from 50 to 83 Mpa

Optimised:

Max. warpage 1.5 mm

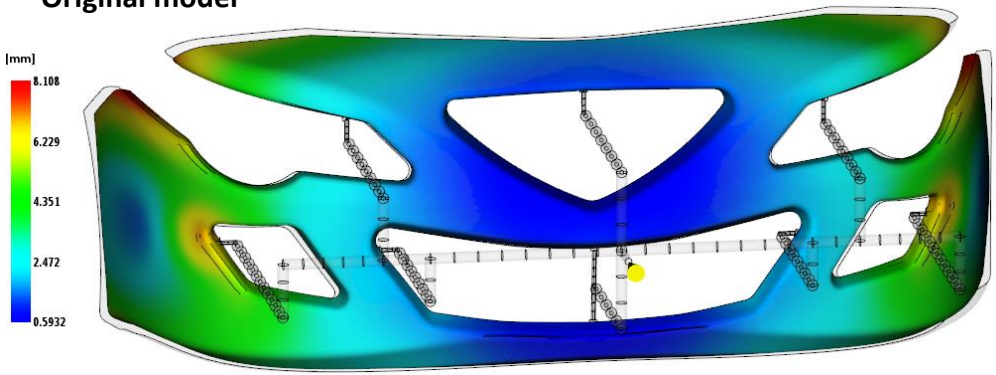
Representations at same scale

SETTING BOUNDARY CONDITIONS

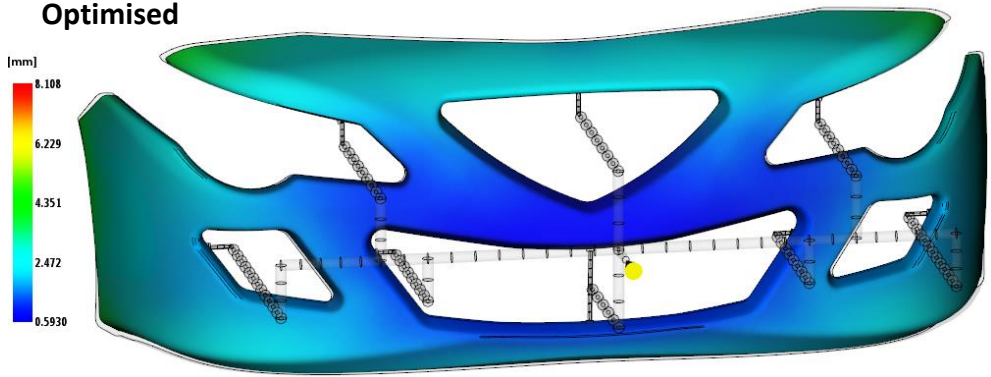
- Setting and varying absolute boundary conditions for parameters
- New results real-time

DIGITAL TWIN – WARPAGE

Original model



Optimised



Original model:

Max. warpage 8.0 mm

Packing pressure level fixed at 50 Mpa

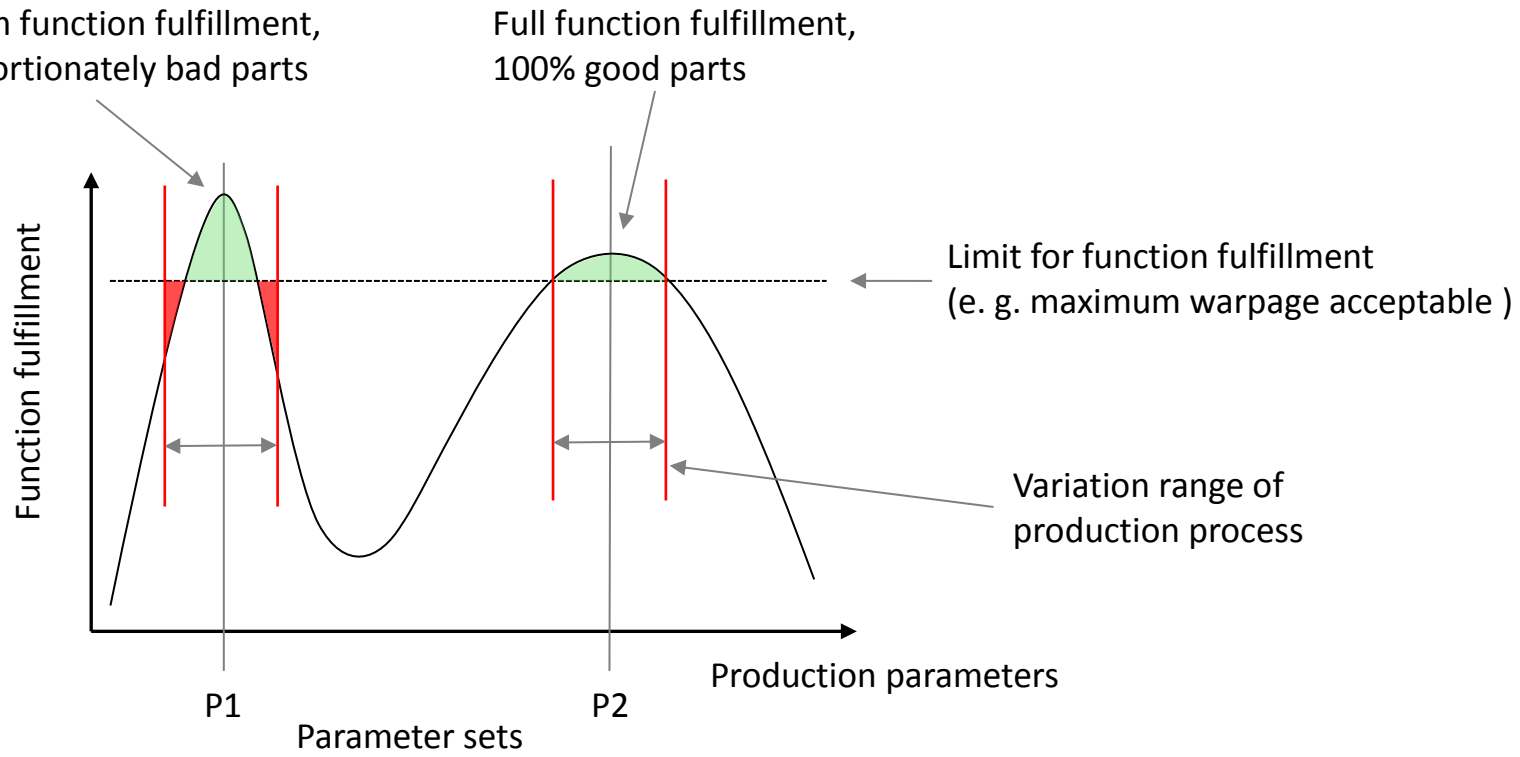
Improvement: 45 %

Optimised:

Max. warpage 4.4 mm

Darstellungen gleich skaliert

ROBUSTNESS REGARDING FUNCTION FULFILLMENT AND PRODUCTION



Thank you for your attention!

M.TEC

K.D. FEDDERSEN

Member of the Feddersen Group