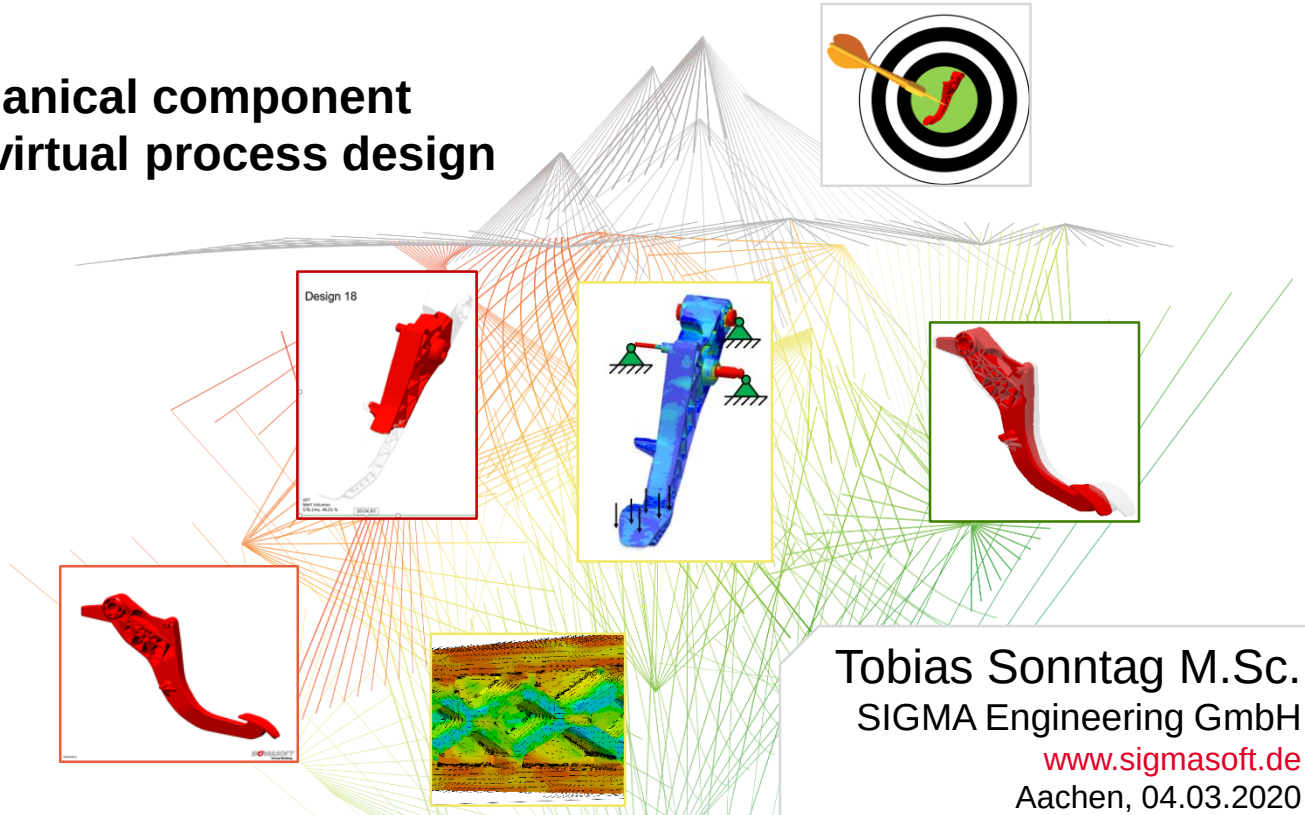
Optimized mechanical component properties through virtual process design



Tobias Sonntag M.Sc.
SIGMA Engineering GmbH
www.sigmasoft.de
Aachen, 04.03.2020

SIGMASOFT® Virtual Molding

Optimized mechanical component properties through virtual process design

Intention

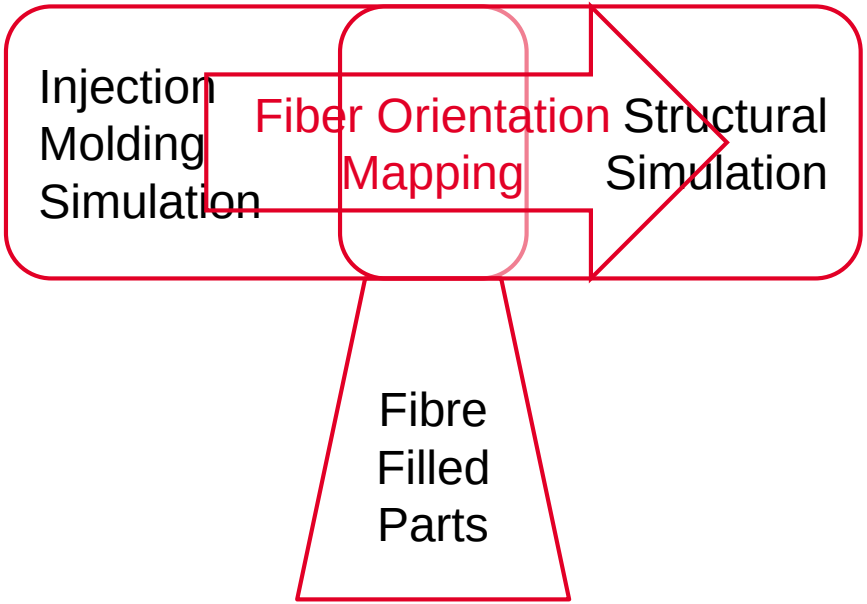
Injection Molding Simulation

Structural Simulation

Fibre Filled Parts

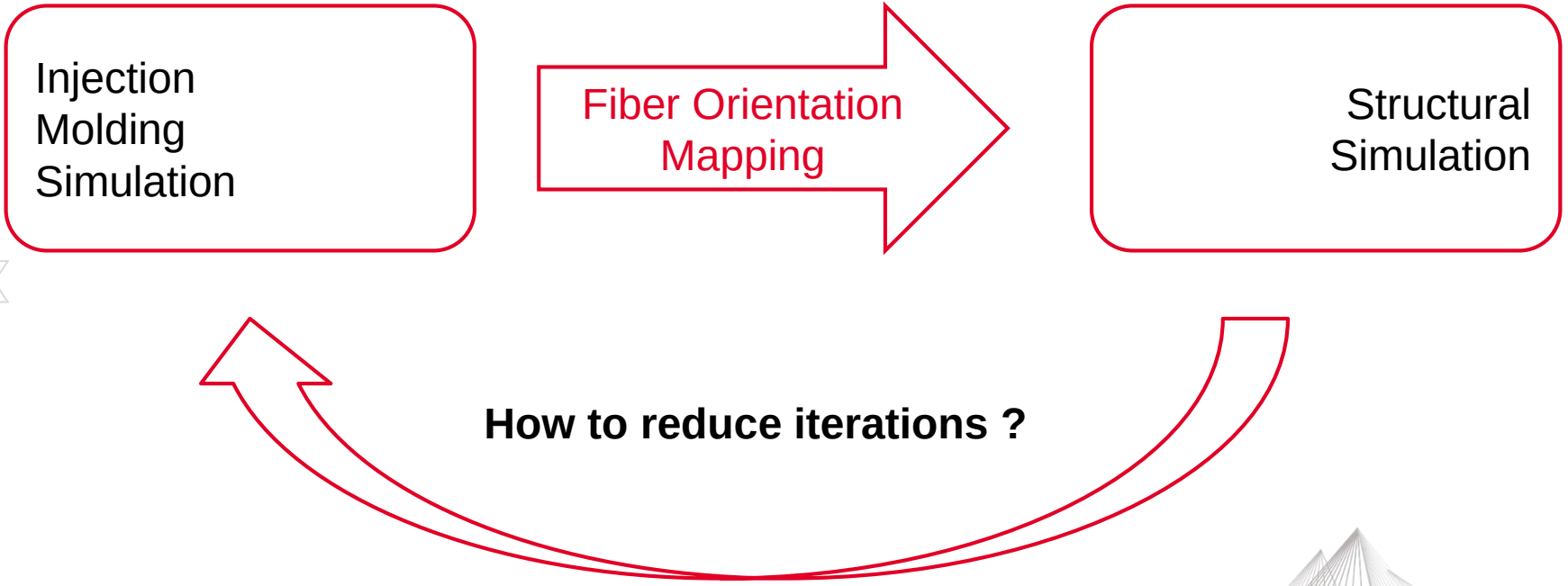
Optimized mechanical component properties through virtual process design

Intention



SIGMASOFT® Virtual Molding

Intention

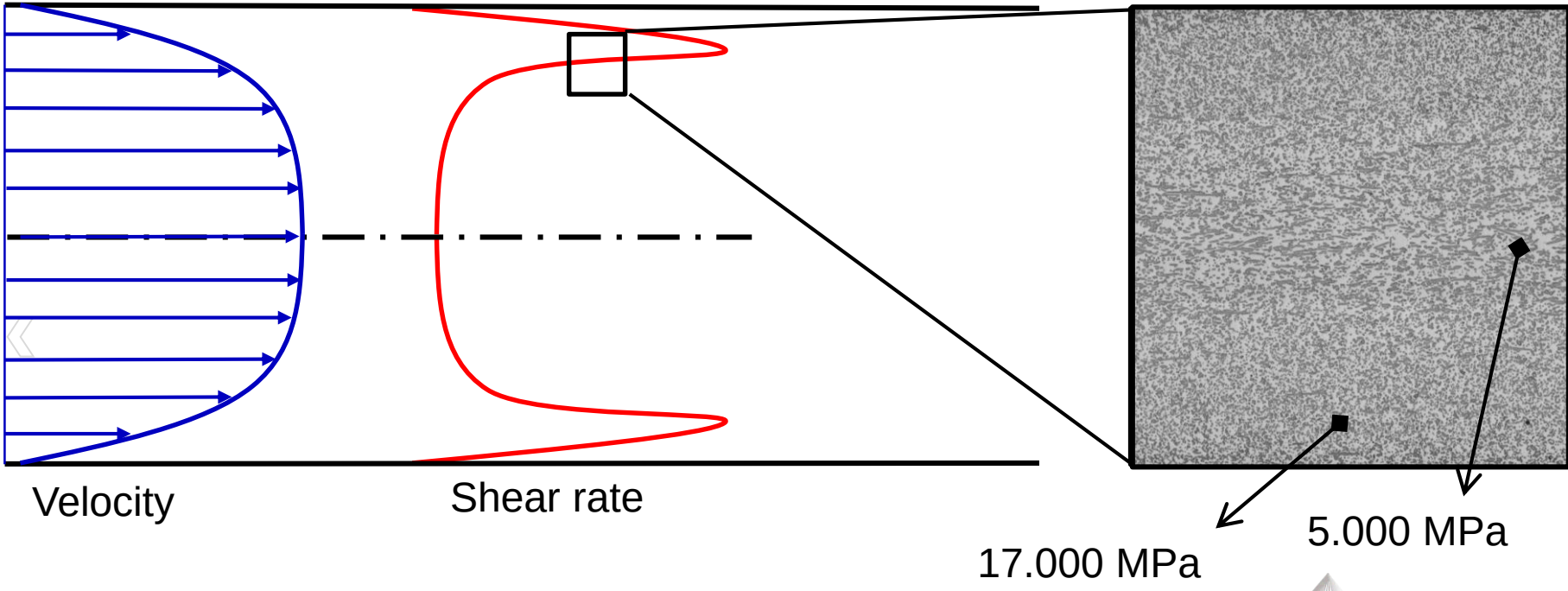


Anisotropic Material behaviour

The problem behind is…

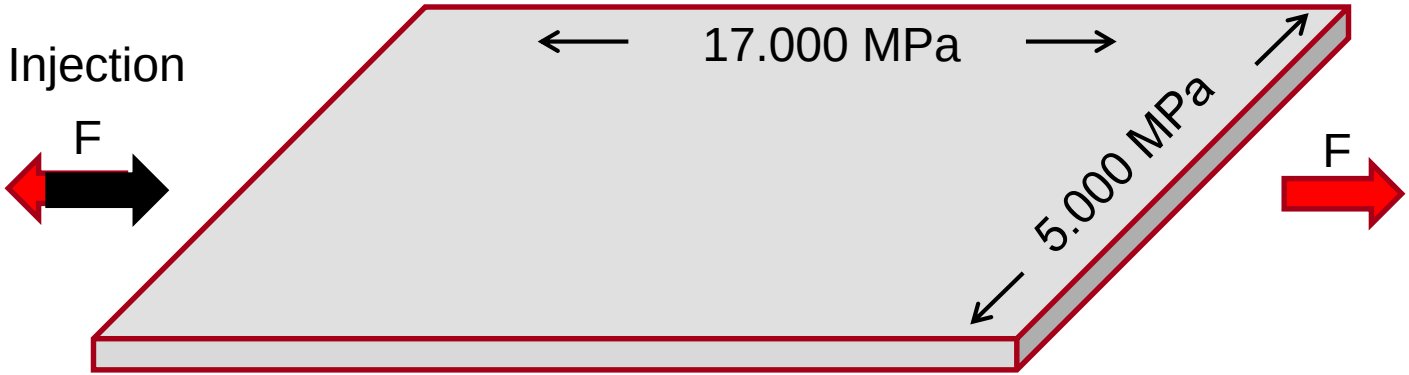
Aluminium		PA GF
Density: 2.7 g/cm³		Density: 1.5 g/cm³
E-Modulus: 70.000 MPa		E-Modulus: 17.000 MPa
Shrinkage: 1,25 %		Shrinkage: 0,3 / 0,9 %

Which factor drives the fiber orientation ?



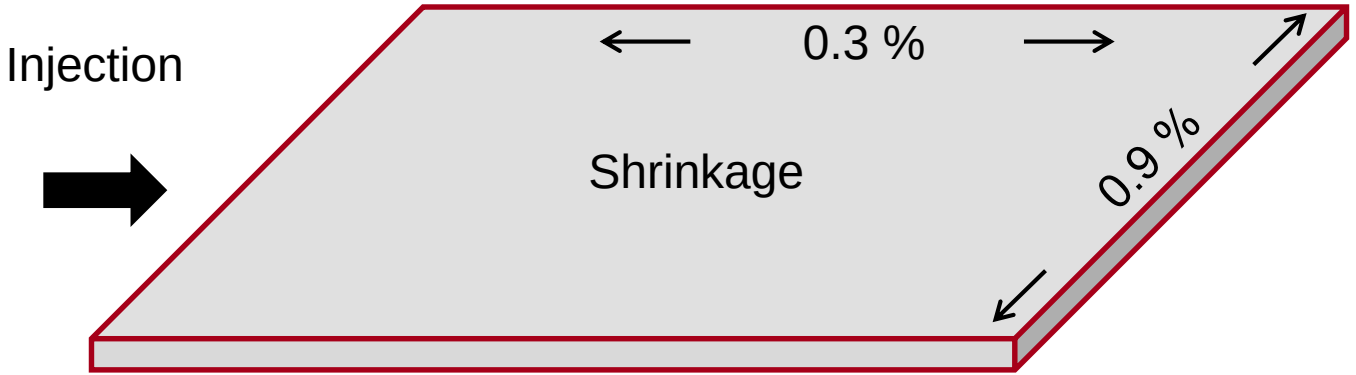
Use Fiber Orientation In A Targeted Purpose…

…on the one hand to guarantee mechanical component stability in the loading direction



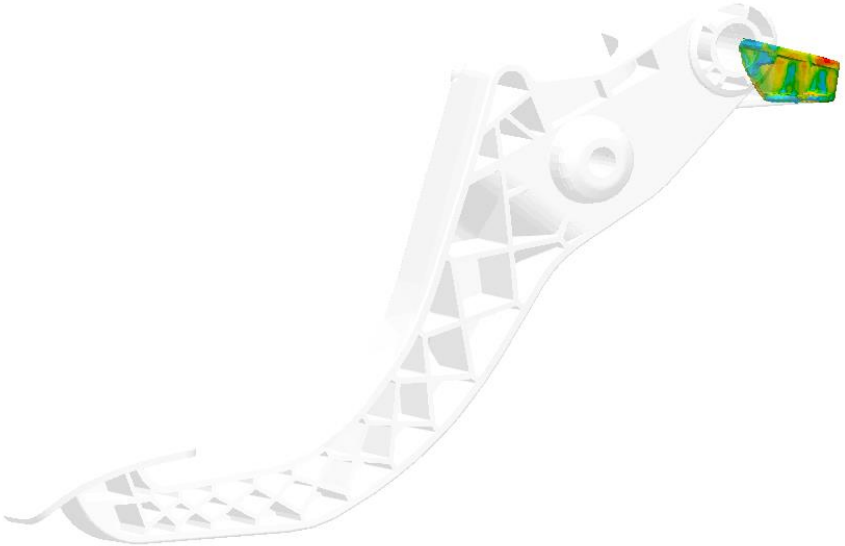
Use Fiber Orientation In A Targeted Manner…

… and one the other hand to keep component distortion low



The Challenge With Glass Fiber Filled Parts

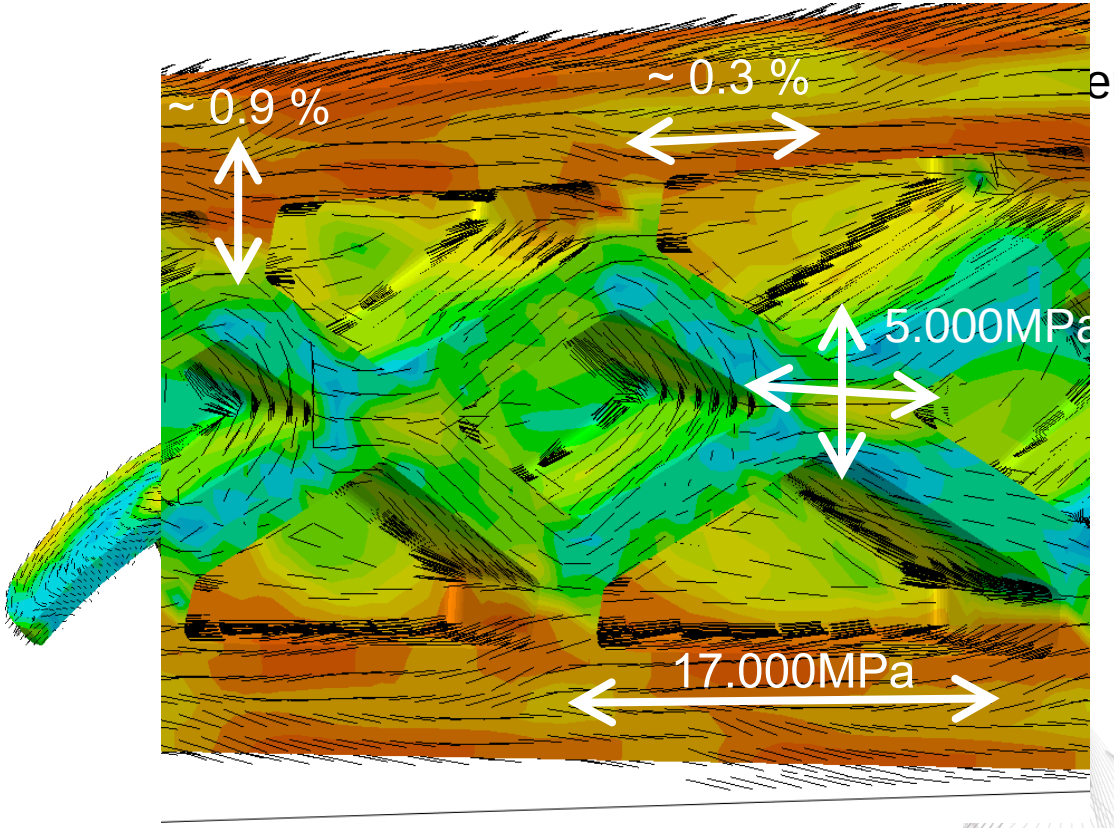
Fiber orientation depending on the injection point



Cycle 1, Filling, Fiber
24.3ms, 2.03 %
3D-Faserorientierung

SIGMASOFT Virtual Molding

The Challenge With Glass Fiber Filled Parts



ents?

Cycle 1, Filling, Fiber
1.201s, 100.00 %
3D-Faserorientierung

One Target

Use fiber orientation in a targeted purpose in order to fulfill the requirements

Typical requirements

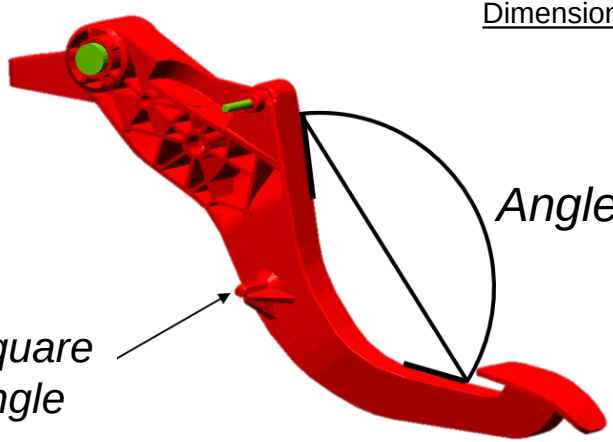
Mechancial behavior

Process behavior

- depend mainly on the injection point
- process and mechanical challenge are unavoidably linked together by the fiber

Requirements to the fibre orientation

Flatness



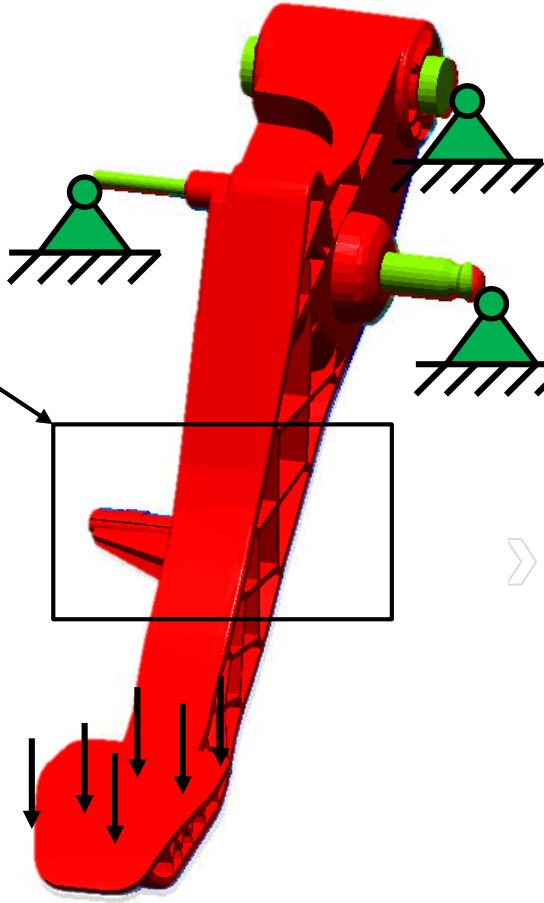
Angle

Square Angle

Dimensional accuracy

Mechanical stability

Reduce strain



These requirements are driven by…

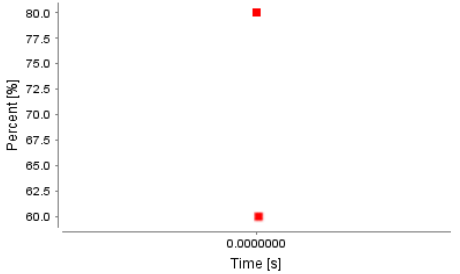
Design Variables [Possible designs: 84]

…

Design Variables

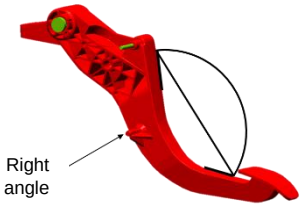
	Design Variable	Selection
☑	Geometry geometry_exchange_001 - Activated item	1 | Vorne_drauf 2 | Seitlich_Zapfen 3 | Mittig_drauf_1 4 | Mittig_drauf_2 5 | Mittig_drauf_3 6 | Mittig_drauf_4 7 | Mittig_drauf_5 8 | Mittig_drauf_6 9 | Mittig_drauf_7 10 | Mittig_unten_3 11 | Mittig_unten_2 12 | Mittig_unten_1 13 | Mittig_unten_5 14 | Mittig_unten_4

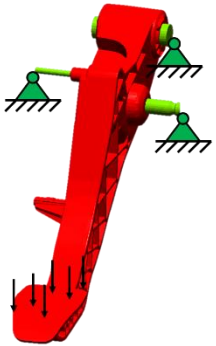
	Design Variable	Dataset List
☑	Part Material Class - Material Data	SIGMA/ULTRAMID_A3WG3 SIGMA/ULTRAMID_A3WG6 SIGMA/ULTRAMID_A3WG10

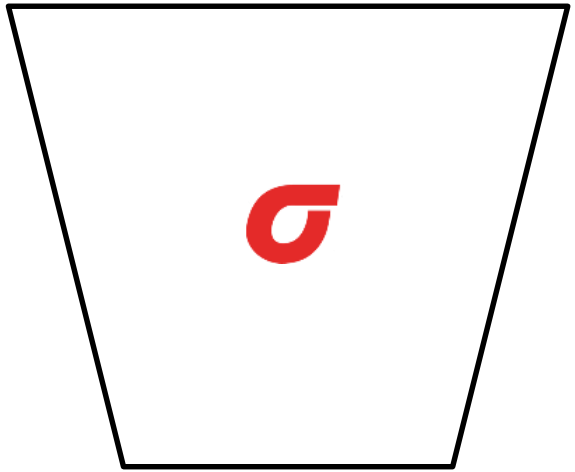
	Design Variable	Variation
☑	Packing - Relative Pressure Variation	

	Variation Parameter	Lower Limit (%)	Upper Limit (%)	Step (%)
☑	Y0	60.0	80.0	20.0

Design Of Experiments – Required fiber orientation







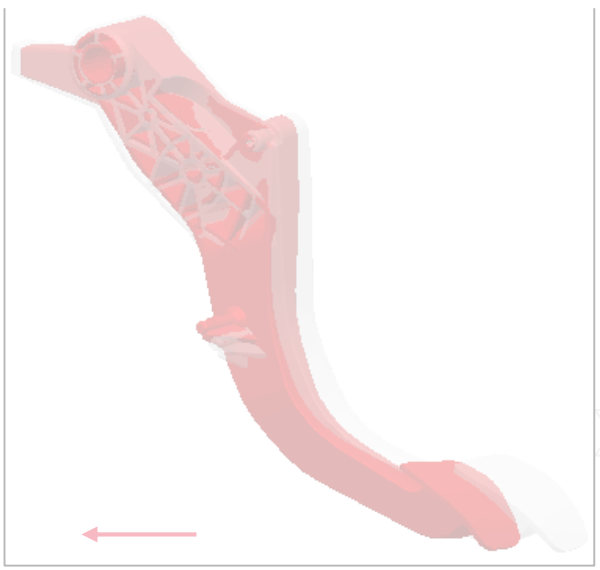
14 injection points

2 packing pressure level

PA 15 GF
PA 30 GF
PA 50 GF

SIGMASOFT® Virtual Molding

Which Is The Best Design ?



Design 16

Design 79

Design 14

But what about the strain?
And the filling pressure?

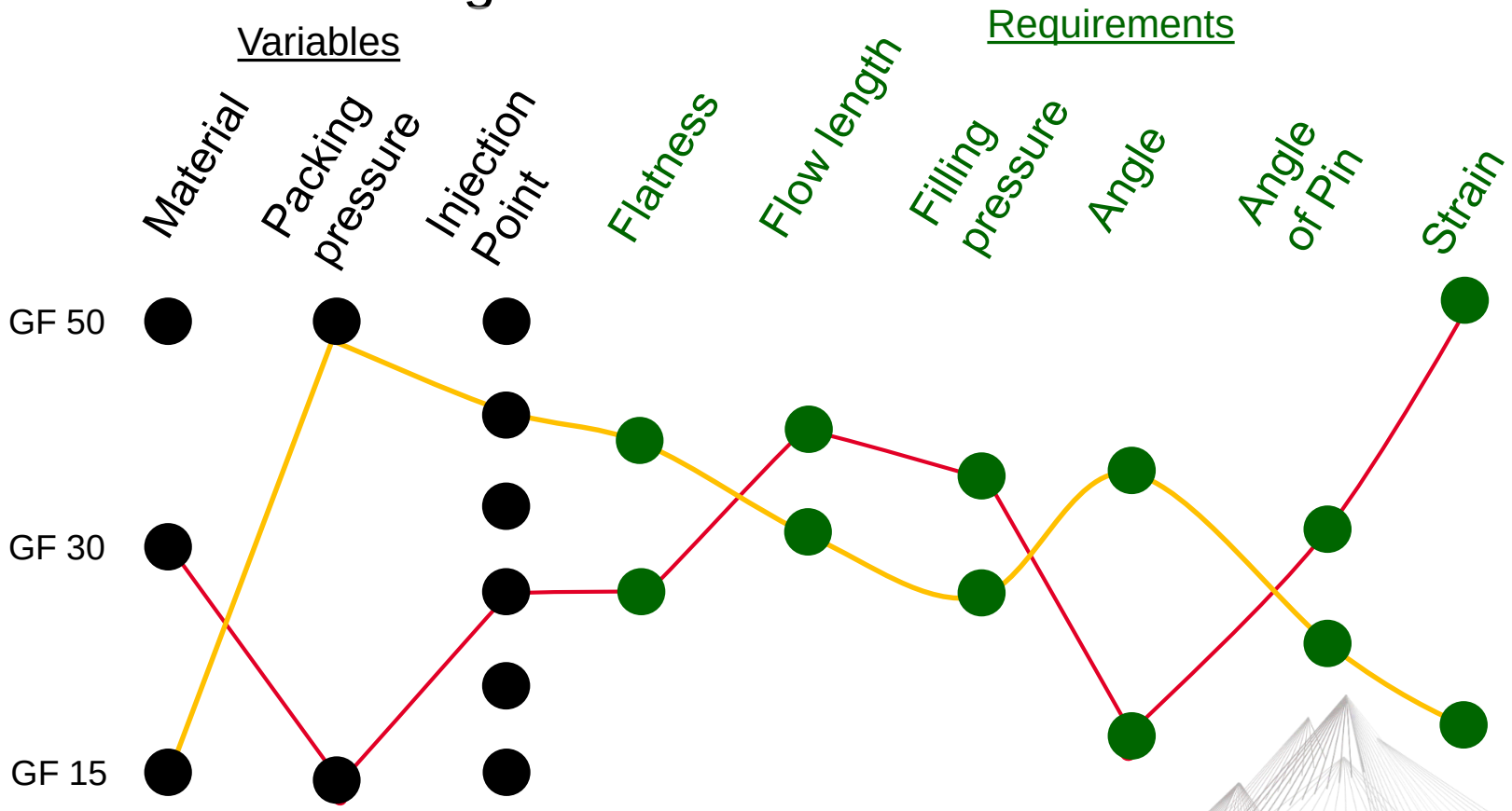
Automatic Ranking

Rank	Design	Dehnung (-)	Ebenheit (-)	Fließweg (-)	Fuelldruck (-)	Winkel_Pedal (-)	Winkel_Zapfen (-)
Rank 1	Design 62	0.755	0.077	221.09	392.05	0.225	0.0114
Rank 3	Design 61	0.679	0.0799	232.82	373.6	0.244	0.0296
Rank 4	Design 19	0.703	0.0805	232.82	373.6	0.248	0.0318
Rank 5	Design 63	0.725	0.0314	231.14	315.26	0.273	0.084
Rank 6	Design 21	0.73	0.0411	231.14	315.26	0.279	0.0826
Rank 7	Design 60	0.726	0.15	253.22	382.64	0.177	0.0983
Rank 8	Design 66	0.898	0.241	270.39	416.88	0.0648	0.0599
Rank 9	Design 18	0.752	0.15	253.22	382.64	0.181	0.101
Rank 10	Design 24	0.898	0.256	270.39	416.88	0.065	0.0624
Rank 11	Design 58	0.745	0.438	231.63	323.26	0.0198	0.245
Rank 12	Design 59	0.781	0.0866	274.96	430.98	0.167	0.0873
Rank 13	Design 67	0.675	0.192	305.65	449.28	0.0625	0.111
Rank 14	Design 16	0.768	0.459	231.63	323.26	0.0201	0.25
Rank 15	Design 17	0.808	0.0895	274.96	430.98	0.17	0.0926
Rank 16	Design 25	0.693	0.21	305.65	449.28	0.0628	0.114
Rank 17	Design 48	1.4	0.0478	221.41	364.0	0.204	0.0788
Rank 18	Design 68	0.694	0.147	334.12	488.89	0.0631	0.149
Rank 19	Design 47	1.37	0.0829	237.01	370.95	0.21	0.0733
Rank 20	Design 6	1.45	0.0791	221.41	364.0	0.217	0.0824
Rank 21	Design 26	0.714	0.166	334.12	488.89	0.0627	0.154
Rank 22	Design 65	0.709	0.0707	334.13	440.92	0.14	0.161
Rank 23	Design 5	1.42	0.071	237.01	370.95	0.217	0.0786
Rank 24	Design 76	0.841	0.14	221.14	532.27	0.283	0.0862
Rank 25	Design 70	0.769	0.531	228.07	293.37	0.0597	0.346
Rank 26	Design 23	0.731	0.0839	334.13	440.92	0.144	0.17
Rank 27	Design 64	0.708	0.0484	305.56	387.37	0.259	0.163
Rank 28	Design 80	0.91	0.336	269.39	579.74	0.0614	0.0817
Rank 29	Design 46	1.4	0.116	258.38	381.45	0.135	0.137
Rank 30	Design 75	0.765	0.0714	232.94	526.63	0.325	0.114
Rank 31	Design 34	0.862	0.159	221.14	532.27	0.294	0.083
Rank 32	Design 52	1.35	0.365	269.09	408.36	0.0659	0.0442
Rank 33	Design 38	0.918	0.36	269.39	579.74	0.0617	0.0862
Rank 34	Design 28	0.789	0.551	228.07	293.37	0.0626	0.353
Rank 35	Design 49	1.42	0.0175	232.47	299.37	0.276	0.154
Rank 36	Design 22	0.731	0.062	305.56	387.37	0.264	0.17
Rank 37	Design 33	0.785	0.0668	232.94	526.63	0.338	0.119
Rank 38	Design 4	1.46	0.11	258.38	381.45	0.142	0.145
Rank 39	Design 10	1.39	0.395	269.09	408.36	0.0663	0.0522
Rank 40	Design 7	1.46	0.0367	232.47	299.37	0.287	0.157
Rank 41	Design 77	0.861	0.12	230.9	444.98	0.319	0.206
Rank 42	Design 45	1.46	0.0894	281.93	427.35	0.128	0.144
Rank 43	Design 35	0.879	0.133	230.9	444.98	0.329	0.207
Rank 44	Design 74	0.792	0.134	253.98	541.23	0.243	0.242
Rank 45	Design 3	1.53	0.0866	281.93	427.35	0.134	0.153
Rank 46	Design 51	1.45	0.0717	336.33	426.72	0.09	0.149
Rank 47	Design 81	0.795	0.252	304.24	616.13	0.0588	0.253

… compromise from all goals

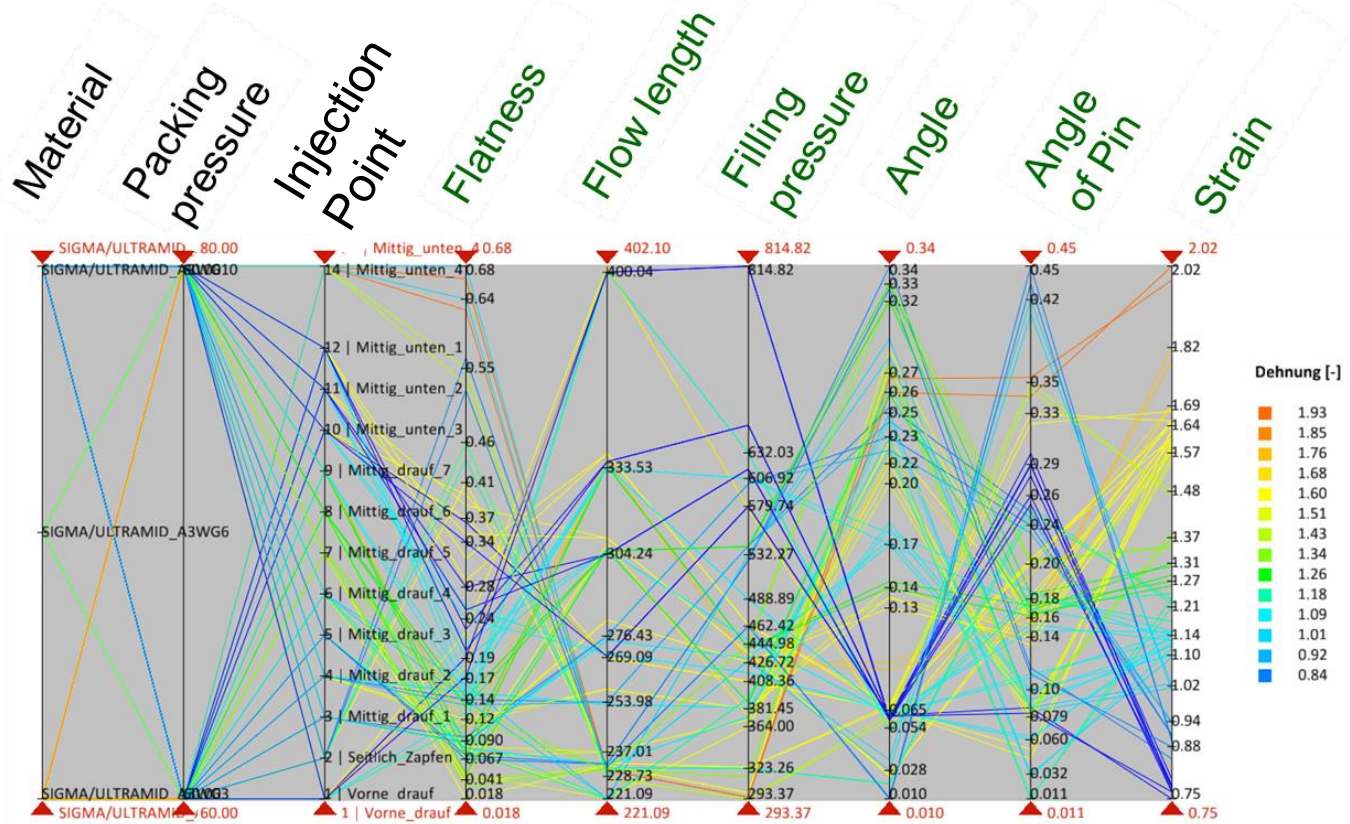
- filling pressure
  - flatness
    - angle
      - strain
        - …

Personal Best Design

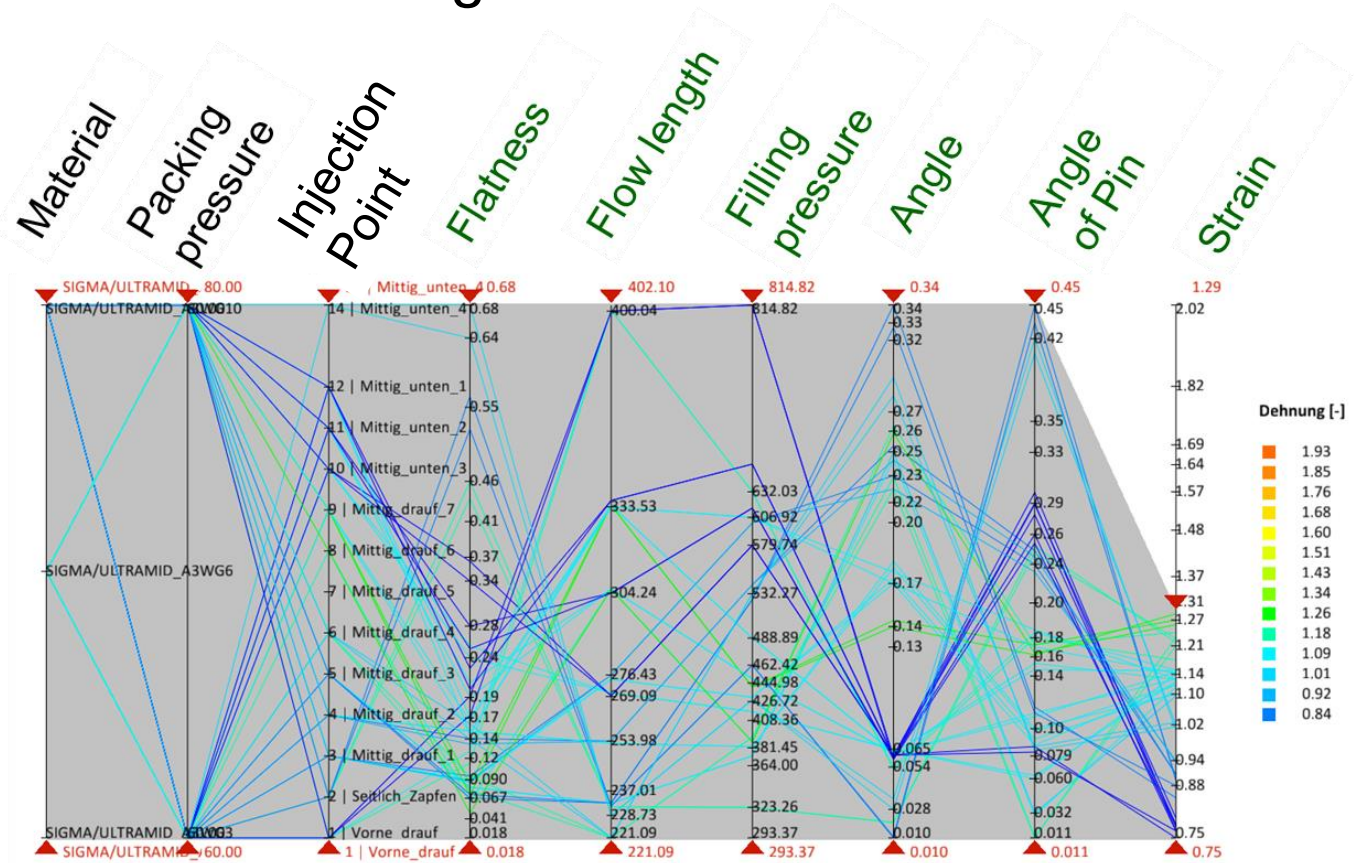


Optimized mechanical component properties through virtual process design

Personal Best Design



Personal Best Design



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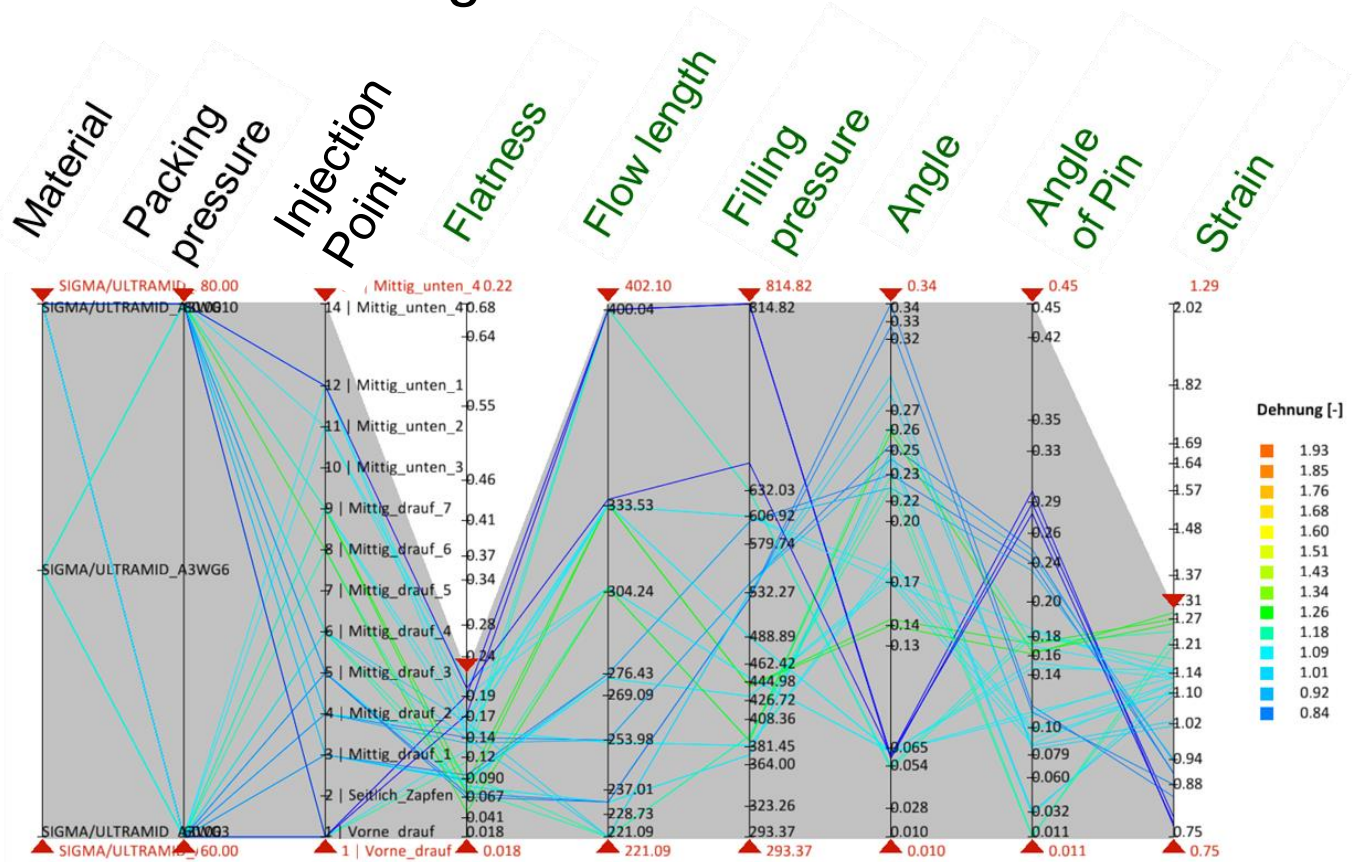

Optimized mechanical component properties through virtual process design

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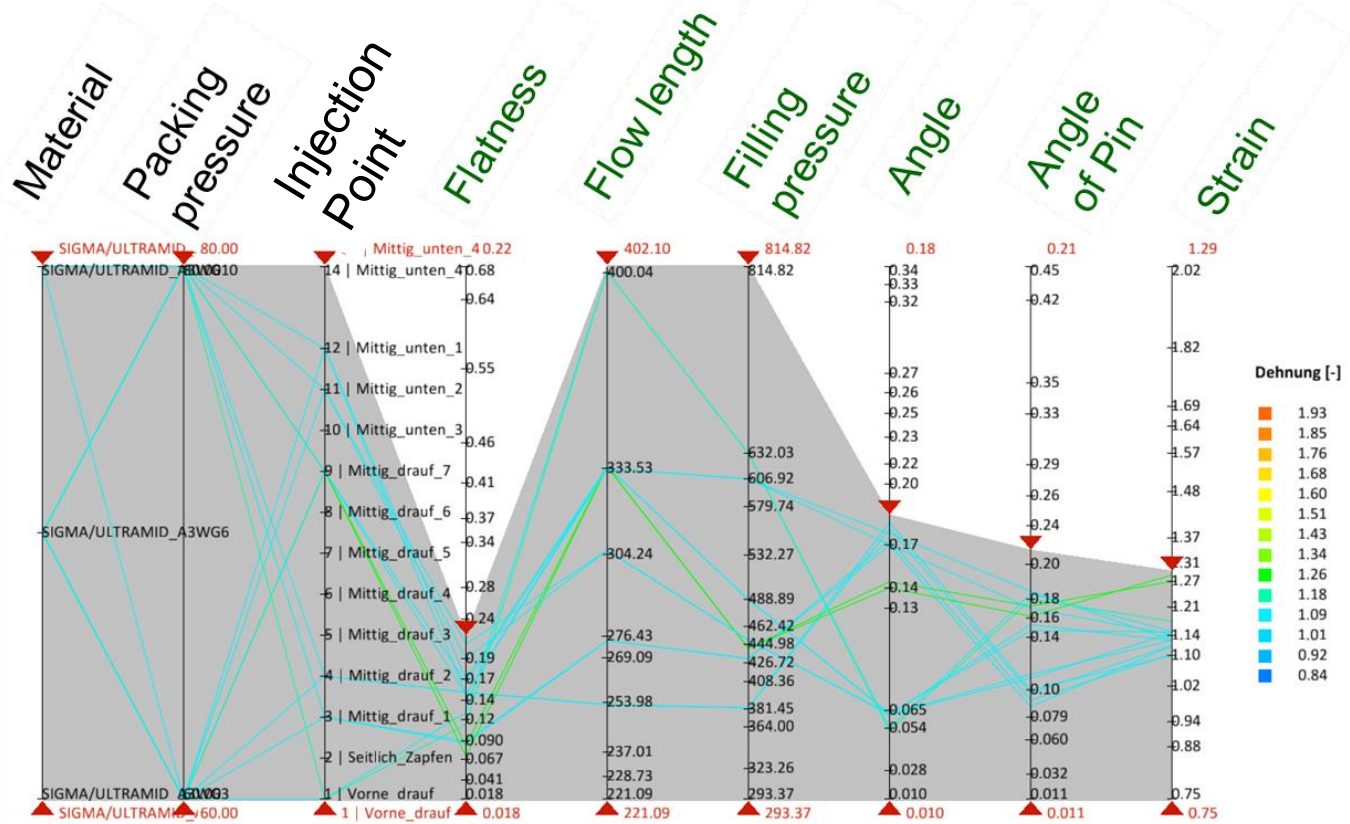

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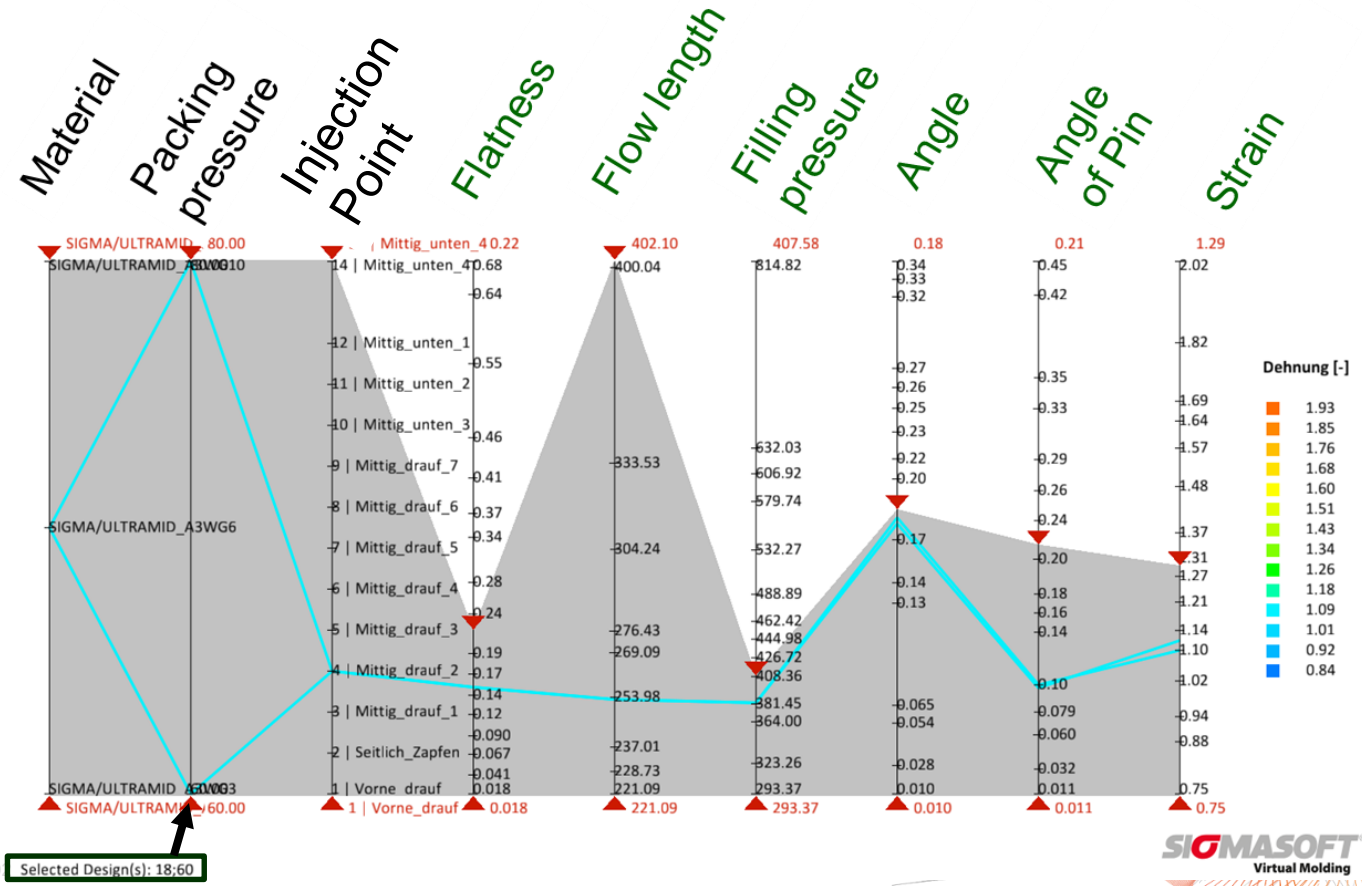
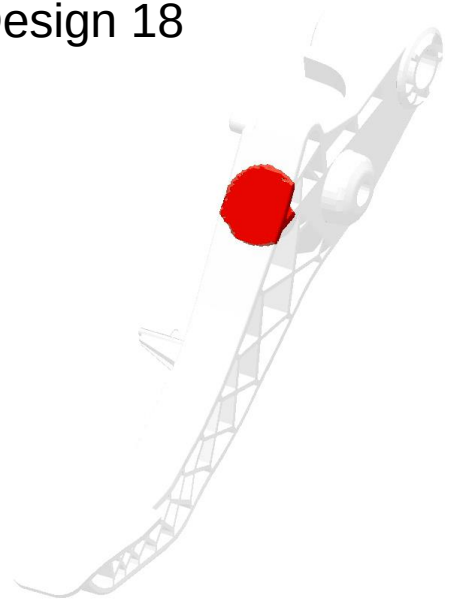
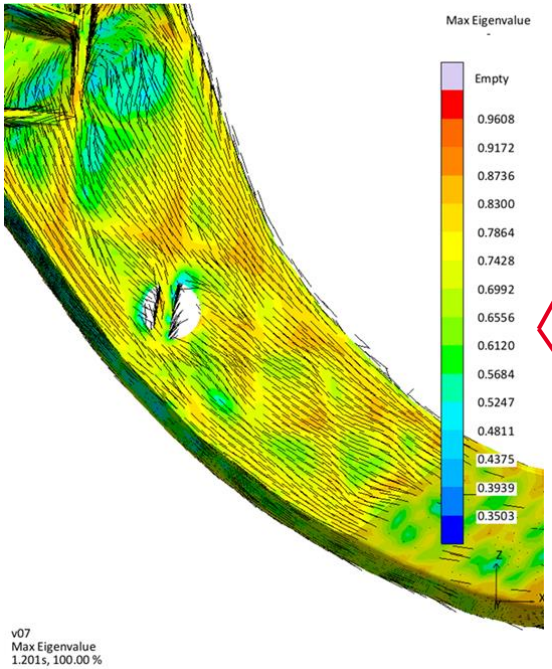


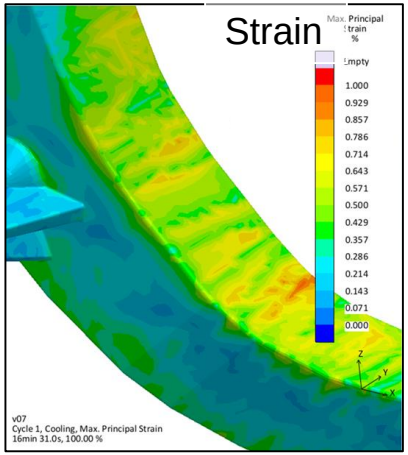
Optimized mechanical component properties through virtual process design

Personal Best Design

Design 18







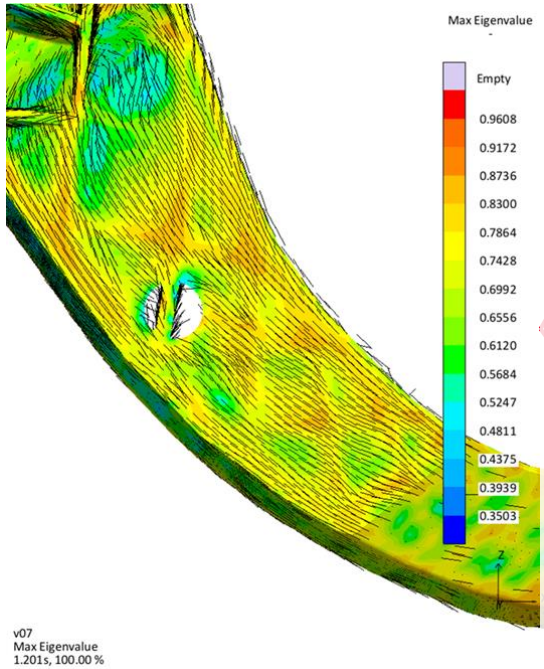
SIGMASOFT® Virtual Molding

Optimized mechanical component properties through virtual process design

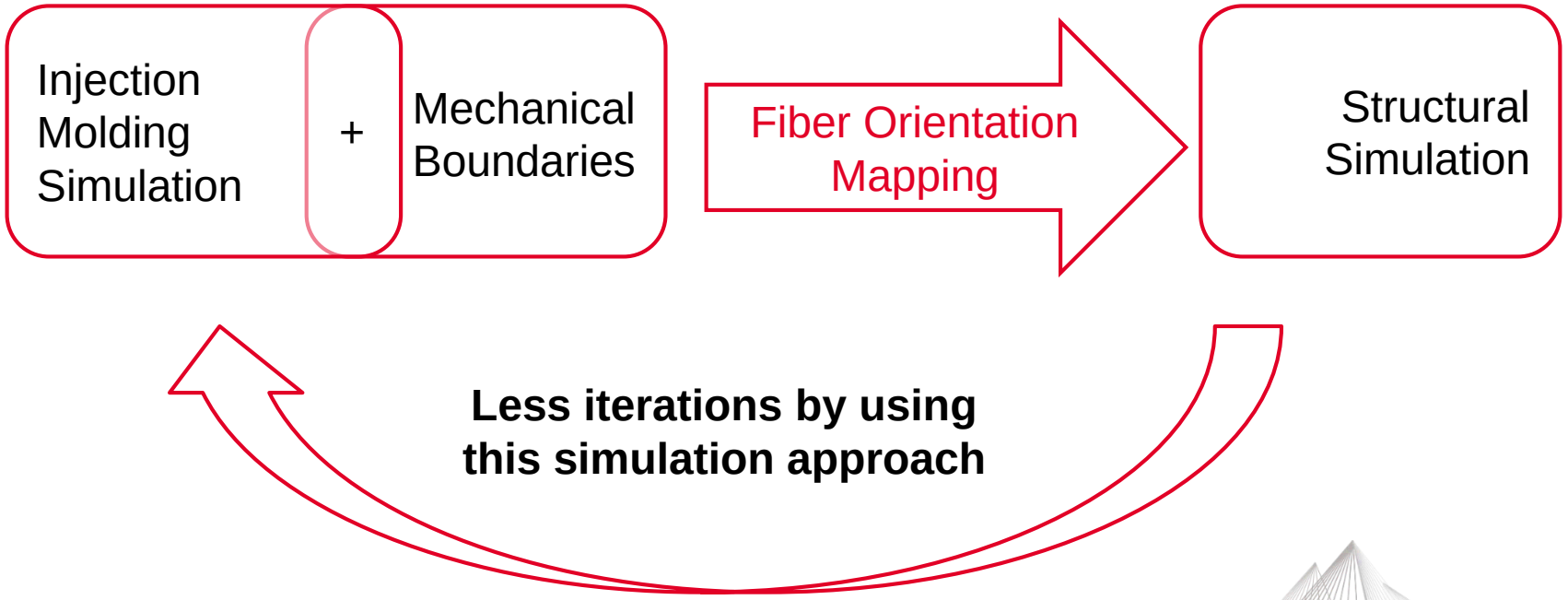
Personal Best Design

Design 18

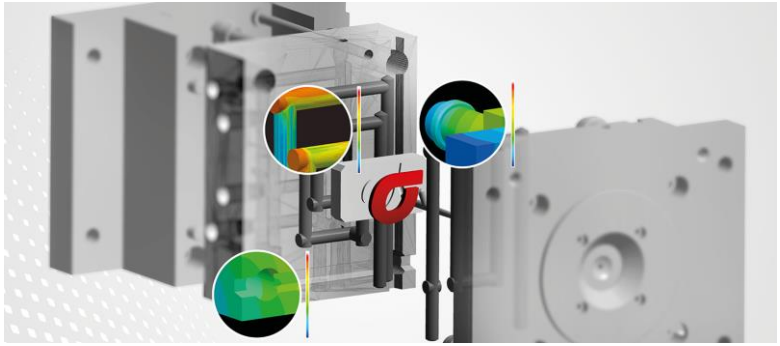
This orientation can be used as a good starting point for further FEM calculation



Summary



Thanks for your attention !



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