Optimization of an actuators magnetic force with optiSLang

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00 List of contents

The company

Information about Hilite Germany GmbH and its products

01 Introduction to Hilite

- automotive company
- founded in 1930
- 1700 employees
- 8 locations on 3 continents
- 550 Mio. € turnover

01 Hilite products

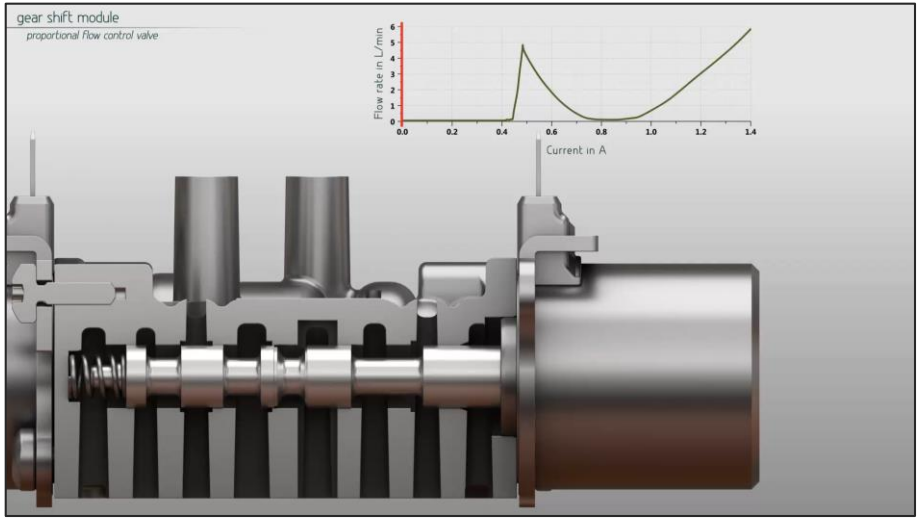
Hilite has 2 major product families

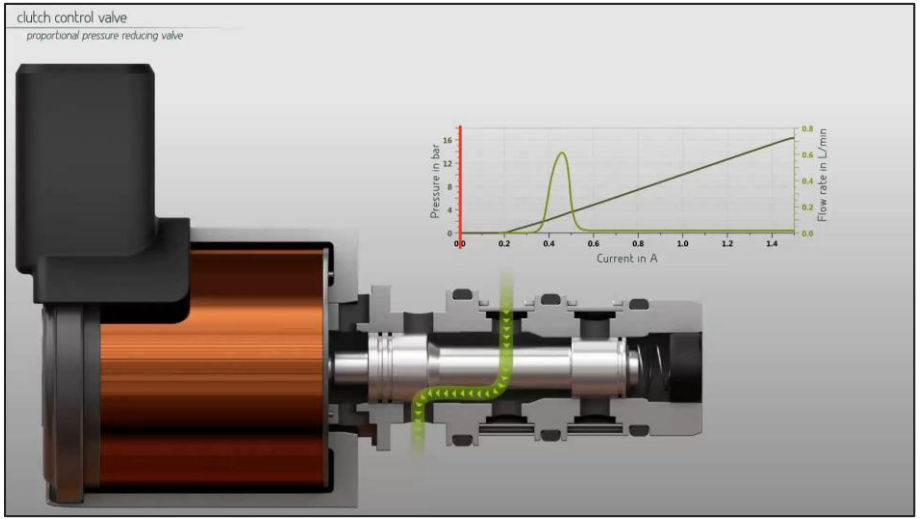
- Engine products
  - Vanecam®
  - Fastphaser®
- Transmission (DCT) valves
  - directional valves
  - pressure proportional valves
  - check valves

The system, objectives and constraints

Optimization combination of Maxwell and OptiSLang that helps to improve Hilite products

02 Valves for DCT

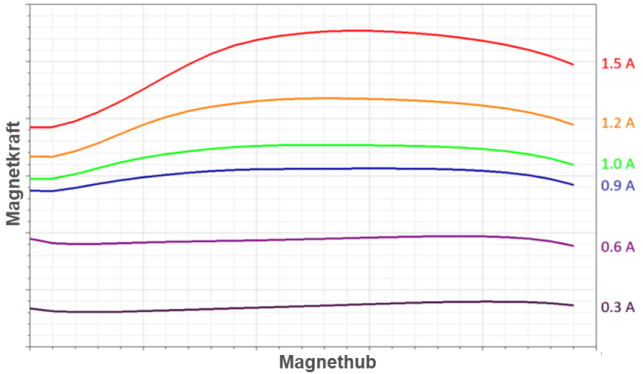




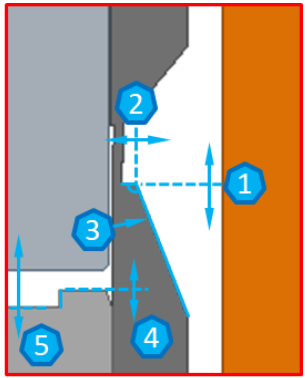
- new actuator for the usage in multiple valves
- changes in initial design lead to various optimization tasks
- objectives depending on characteristic pressure curves of the system

02 Input variation

- due to already existing analyses, the number of parameters could be reduced to 5
- all important parameters are located within the same region of the valve
- the parameters influence the characteristic curves in various ways



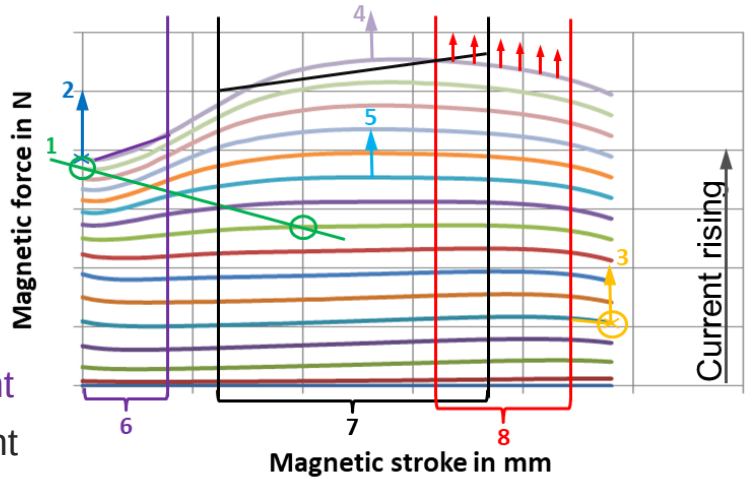
1) VersatzKonus
2) Spitzendicke
3) Konuswinkel
4) HoeheAbsatz
5) Polstopfen-Versatz



03 Criteria for optimization

Constraints:

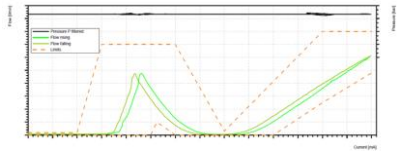
1. lower / upper limit for delta-force
2. lower limit for force at high current (obj. in EA)
3. lower limit for force & slope at low current
4. lower limit for force at max. current (all strokes)
5. lower limit for force at intermediate currents (all strokes)
6. region of lower limit for slope at small strokes and max. current
7. region of lower limit for slope at middle stroke and max. current

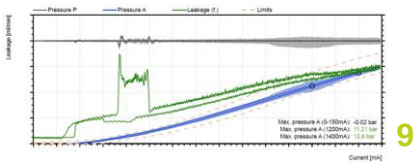


Objective:

8. region of maximum force at high stroke and current

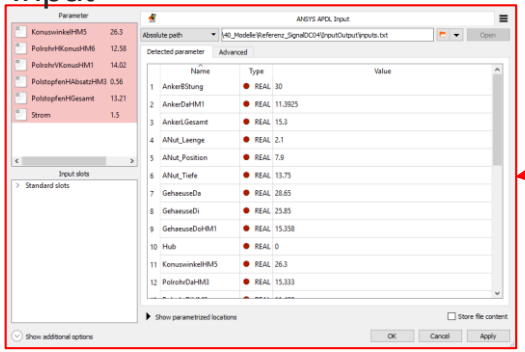
➔ computational effort: 5 currents and up to 14 stroke positions per current

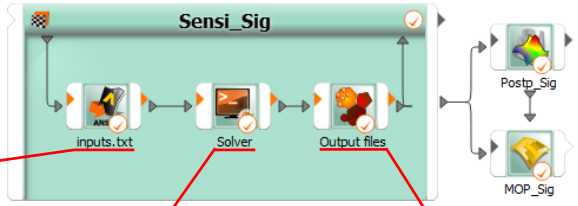




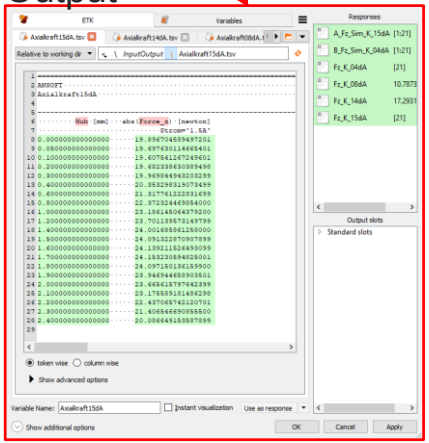
04 Maxwell inside optiSLang

Input

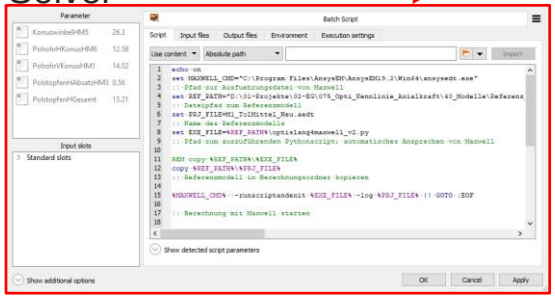




Output

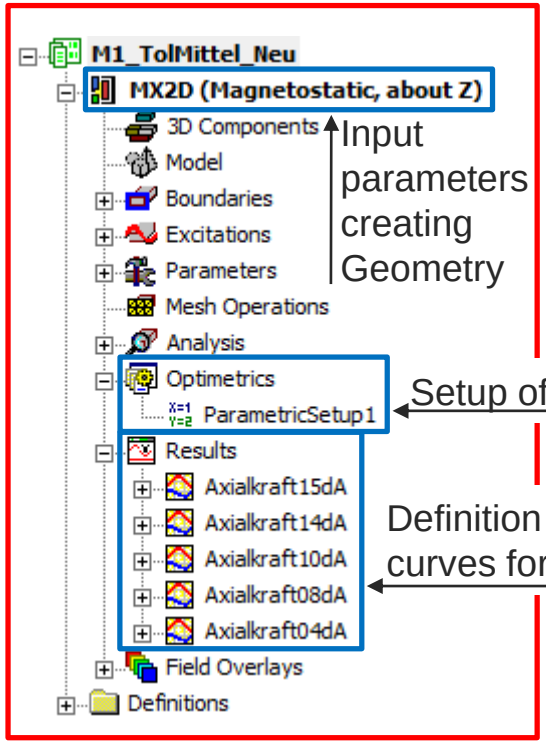


Solver



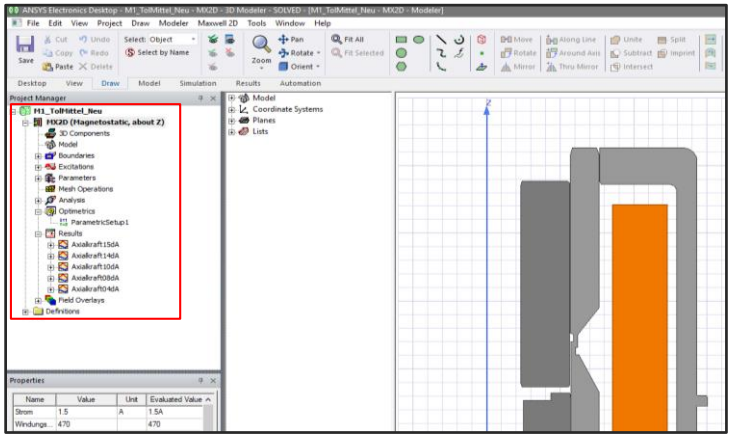
- inputs via txt-file into Maxwell
- batch command for python solver script
- outputs via txt-file from Maxwell
- MOP with information about force and position (characteristic curve)
- optimization of the curves with Maxwell and MOP

04 Maxwell inside optiSLang



Python Solver script for solver usage:

- creating new geometry with Maxwell-template from optiSLang
- starting “Optimetrics” setup to calculate curves
- extracting results to text-files for optiSLang output

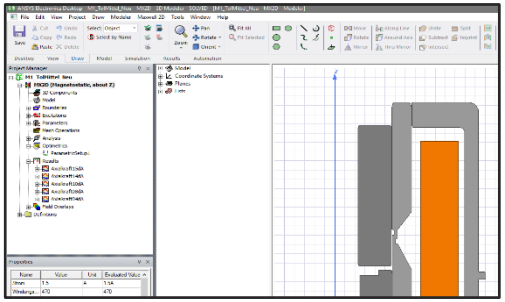


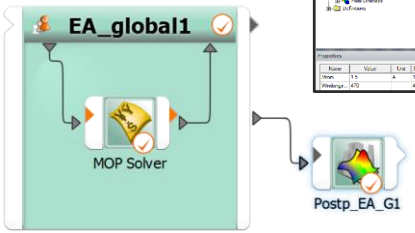
04 Maxwell inside optiSLang

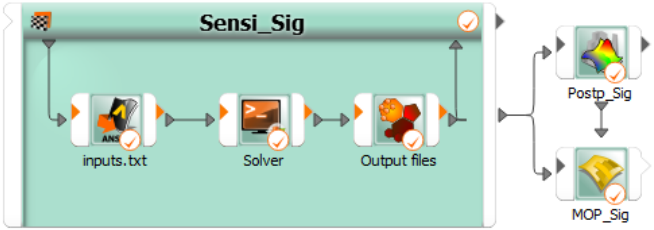
WILLKOMMEN ZU WOST 2019 WEIMARER OPTIMIERUNGS- UND STOCHASTIKTAGE

OptiSLang-Maxwell simulation with lots of calculations possible

- sensitivity analysis to identify important parameters
- pre-optimization of magnetic curves with MOP
- different optimization runs with distinct algorithms (EA & ARSM)





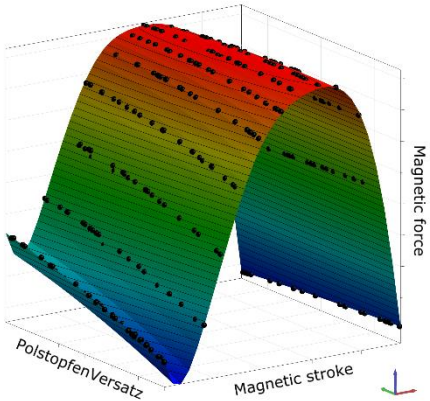


The computation

Search for the best design

05 Sensitivity analysis

- three parameters with large influence on the variation of the axial force
  - “VersatzKonus”
  - “Spitzendicke”
  - “Konuswinkel”
- “HoeheAbsatz” only at small strokes relevant
- “PolstopfenVersatz” with small influence



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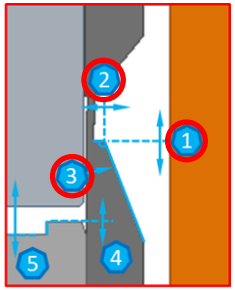
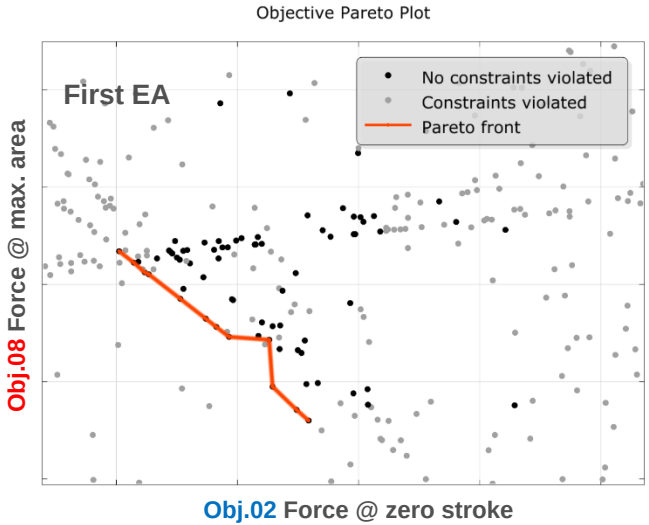
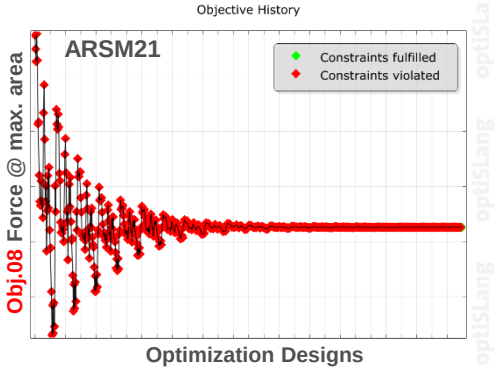


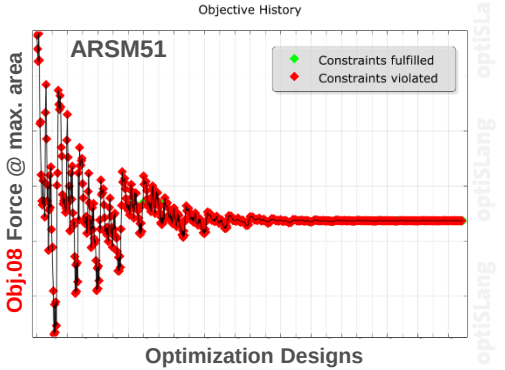
CoP-Matrix

Current	Magnet. stroke	VersatzKonus	Spitzendicke	Konuswinkel	Polstopfen Versatz	HoeheAbsatz	Total
0.4 A	2.4 mm	100.00%	0.45%	0.14%	0.00%	0.01%	100.0%
0.4 A	2.2 mm	99.99%	1.94%	0.49%	0.00%	0.02%	100.0%
1.0 A	2.4 mm	86.26%	15.31%	1.29%	0.00%	0.04%	100.0%
1.0 A	2.2 mm	70.49%	26.34%	3.67%	0.00%	0.01%	100.0%
1.0 A	2.0 mm	40.24%	50.62%	10.64%	0.00%	0.03%	100.0%
1.0 A	1.8 mm	12.22%	69.97%	20.55%	0.06%	0.00%	100.0%
1.0 A	1.6 mm	11.74%	60.90%	30.62%	0.12%	0.29%	100.0%
1.0 A	1.4 mm	23.71%	41.12%	37.79%	0.11%	0.61%	100.0%
1.0 A	1.0 mm	51.73%	8.06%	43.94%	0.76%	3.12%	100.0%
1.0 A	0.6 mm	67.03%	21.49%	6.21%	2.36%	9.40%	100.0%
1.0 A	0.2 mm	44.47%	32.67%	7.48%	1.34%	15.33%	100.0%
1.0 A	0.0 mm	36.49%	27.47%	11.46%	0.89%	26.87%	100.0%
1.5 A	2.4 mm	73.01%	22.96%	4.04%	0.00%	0.00%	100.0%
1.5 A	2.2 mm	61.63%	31.42%	8.30%	0.00%	0.05%	100.0%
1.5 A	2.0 mm	35.29%	48.19%	18.63%	0.00%	0.11%	100.0%
1.5 A	1.8 mm	10.33%	58.37%	31.86%	0.08%	0.22%	100.0%
1.5 A	1.6 mm	11.60%	47.91%	44.21%	0.32%	0.66%	100.0%
1.5 A	1.4 mm	26.56%	27.84%	46.23%	0.94%	1.59%	100.0%
1.5 A	1.2 mm	49.63%	10.10%	40.83%	1.89%	3.08%	100.0%
1.5 A	1.0 mm	71.05%	5.55%	22.08%	3.50%	5.09%	100.0%
1.5 A	0.8 mm	75.19%	15.18%	5.93%	3.72%	5.59%	100.0%
1.5 A	0.6 mm	65.82%	27.59%	1.99%	3.06%	6.31%	100.0%
1.5 A	0.4 mm	56.34%	32.05%	4.85%	2.08%	7.36%	100.0%
1.5 A	0.2 mm	46.74%	33.67%	10.13%	1.34%	10.16%	100.0%
1.5 A	0.1 mm	42.93%	32.45%	12.70%	1.06%	13.84%	100.0%
1.5 A	0.0 mm	37.11%	29.25%	13.53%	0.89%	19.71%	100.0%
0.8 A	1.0 mm	47.14%	11.99%	45.18%	0.51%	2.11%	100.0%
1.4 A	0.0 mm	37.45%	28.89%	13.87%	1.02%	20.84%	100.0%

05 Optimization results

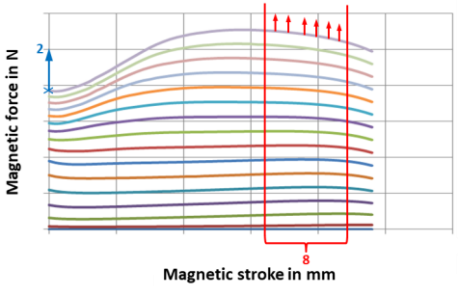




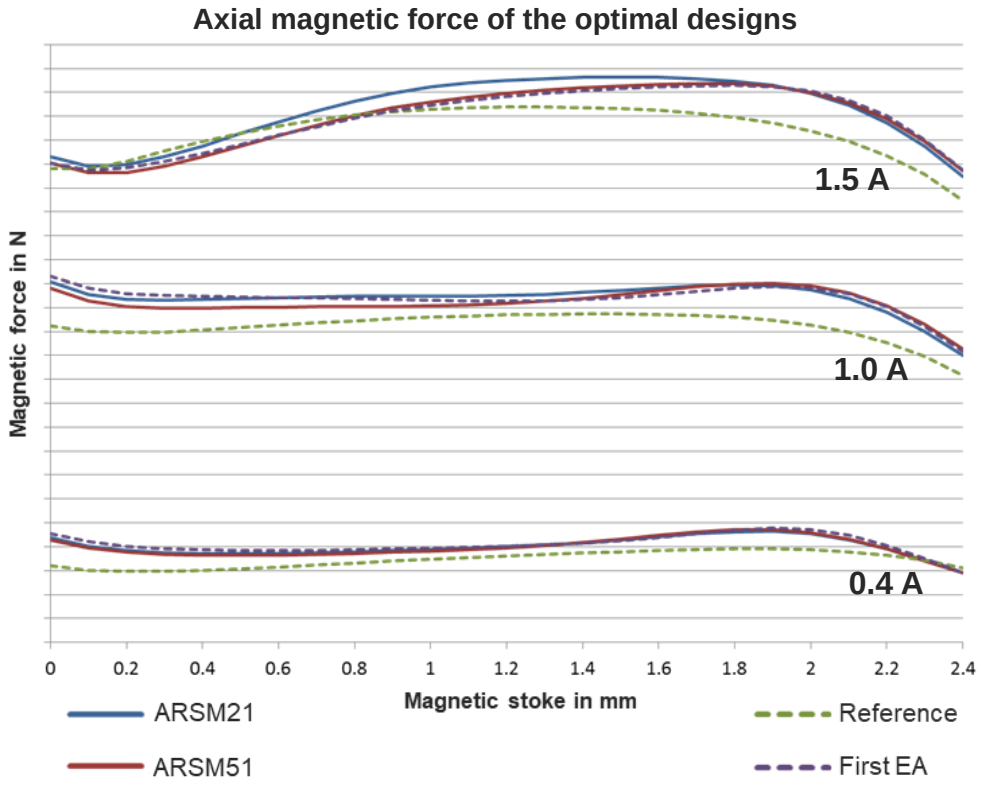


First optimization with evolutionary algorithm

Two following optimizations with different limits ARSM21 & ARSM51

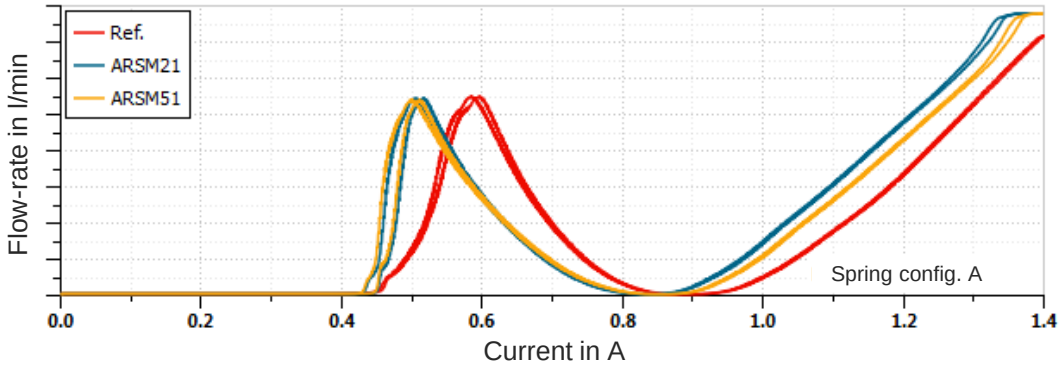


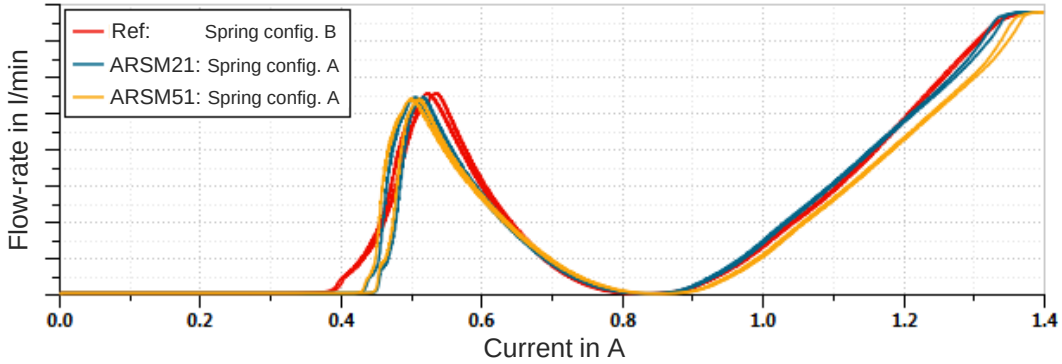
05 Optimization results



- all designs with improved curves when compared to the base model
- all constraints fulfilled
- design “ARSM21” with the largest force at 1.5 mm
- design “ARSM51” with long smooth slope till maximum at 1.7 mm

06 Flow-rate control: Gear change

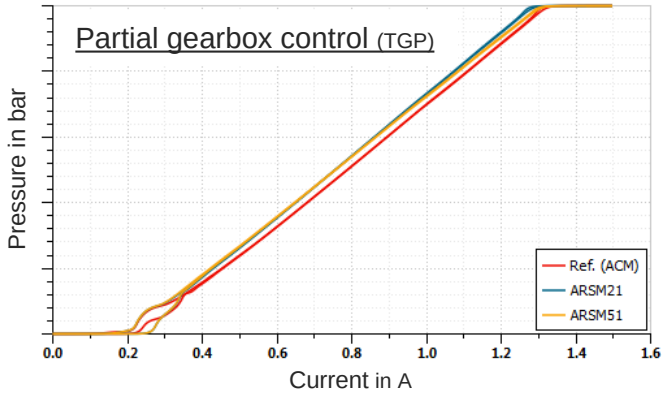


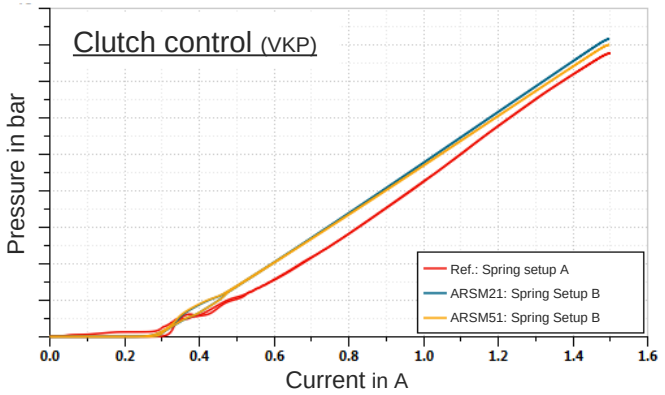


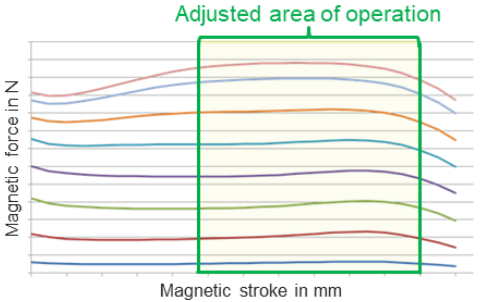
- Difference between ARSM21 and ARSM51 mainly between 0.9 A and 1.3 A
- optimized models reach first peak earlier than reference
- Q-I curve of the optimizations continues decreasing slower towards minimum
- ARSM21 equals the second peak of the base model

06 Pressure control: Clutch & partial gearbox

- both new actuator designs allow the usage in different valve types
- optimized designs achieve slightly better results than reference in TGP
- optimized designs in VKP lead to straight curves and fewer oscillations







In conclusion:

With the possibility of optiSLang and Maxwell working together even complex issues can be solved.

The example shows that the product can be optimally adjusted to its designated function.

With further developments even faster and better results are possible

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Thank you for your attention.

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