Battery cells mechanical properties

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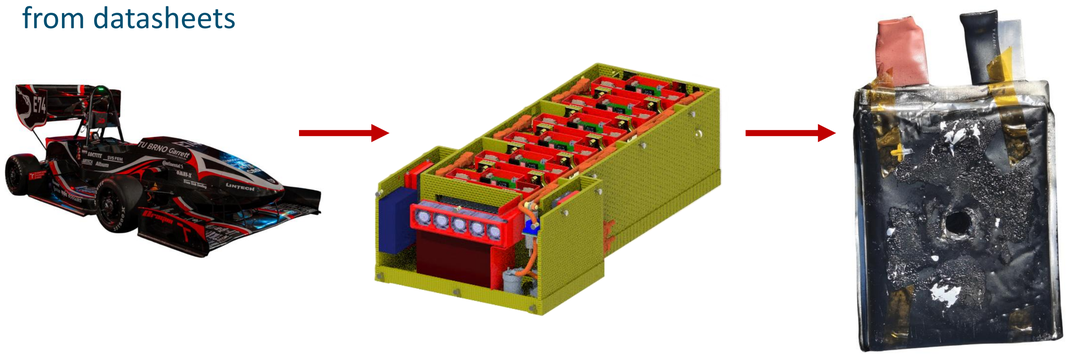
MOTIVATION & OBJECTIVES

- High emphasis on structural safety for the car chassis and outer battery pack
- Mechanical deformation and internal cell limits are historically overlooked in rules
- Pouch cells are highly vulnerable, but their real failure limits are missing from datasheets

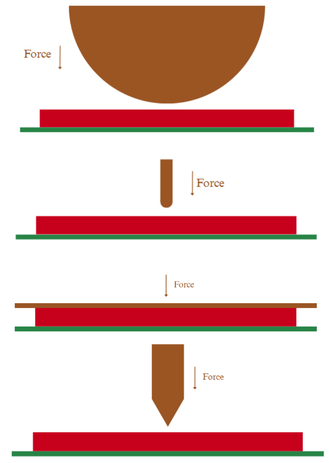


Objective: to develop a simplified mechanical model of a pouch cell

MODELLING APPROACHES

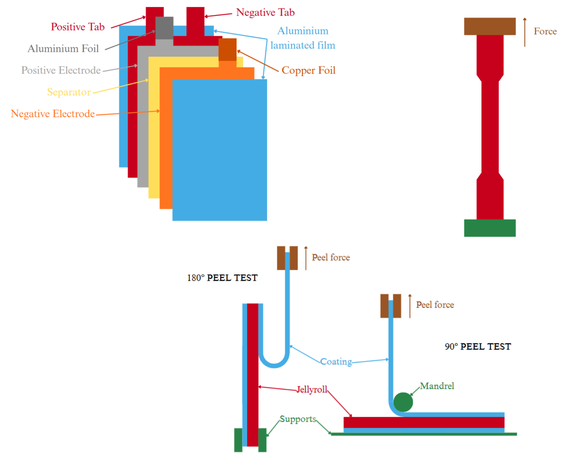
Homogenized model

- Global cell behaviour
- No layer interaction
- Short circuit based on overall deformation
- Faster & simpler

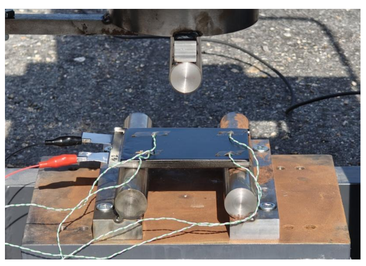


Laminated composite model

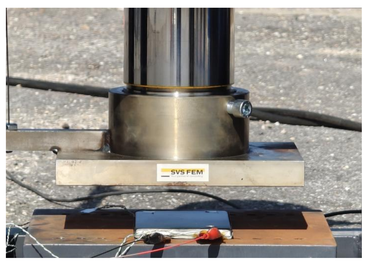
- Each layer modelled separately – tensile test
- Anisotropic
- Adhesion, delamination – peel test
- Failure in specific layer
- More accurate but complex



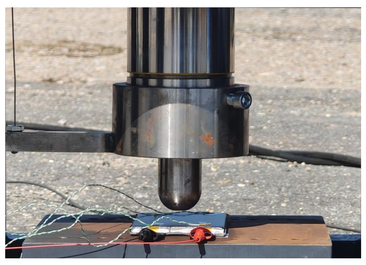
EXPERIMENTAL TESTING



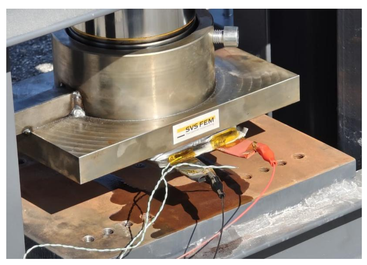
3-point bending



Flat plate compression



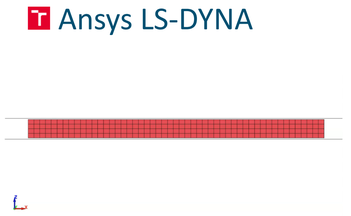
Hemispherical indentation



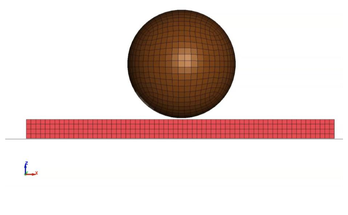
- **Experimental Output:** Force-displacement data
- **Material Modeling:** Converted into a stress-strain curve as input for the material model

NUMERICAL MODEL

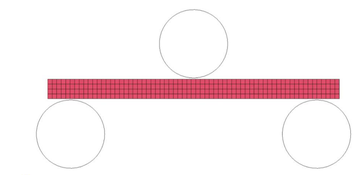
Ansys LS-DYNA



Both explicit and implicit solver

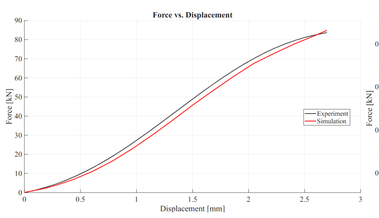


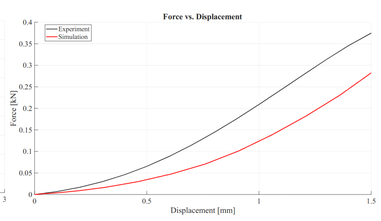
Short circuit limit state ≈ 7 MPa

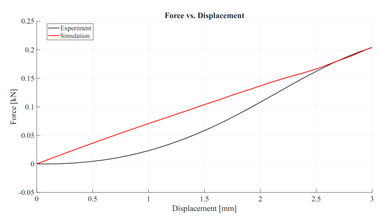


Insufficient bending stiffness

Comparison of experiment and simulation

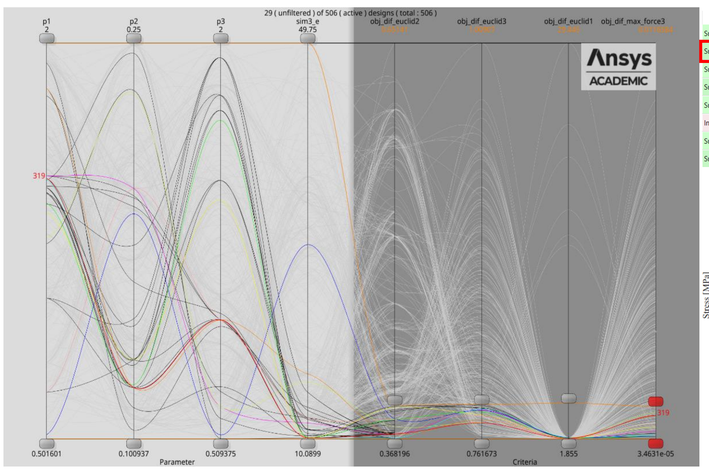




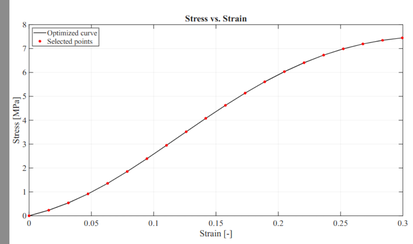


OPTIMIZATION

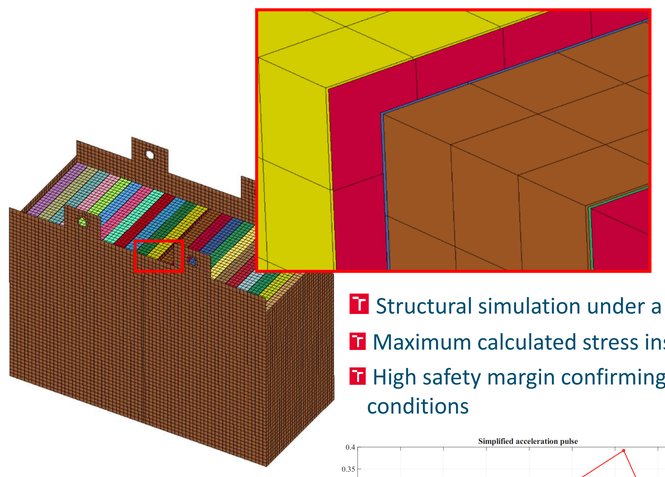
- Optimization loop with over 300 design points in Ansys optiSLang
- Minimization of the error between experimental and simulation curves
- Selection of the best matching configuration (red design)
- Final calibrated stress-strain curve for the material model

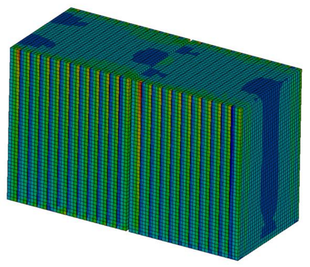


Status	Style	p1	p2	p3	sim3_e	obj_dif_euclid1	obj_dif_euclid2	obj_dif_euclid3	obj_dif_max_force3
Succeeded	Yellow	1.35693	0.13075	1.4075	10.2	2.51785	0.632277	0.933558	0.00440094
Succeeded	Red	1.48783	0.12025	0.9575	10.2	2.32643	0.41085	0.876356	0.00845968
Succeeded	Pink	0.678125	0.19525	0.9575	12.2	2.58268	0.535871	0.923367	0.00561547
Succeeded	Orange	1.8275	0.12025	0.9575	16.6	2.66163	0.403932	0.898468	0.00828779
Succeeded	Magenta	1.4975	0.19525	0.630983	11.6808	2.31755	0.409059	0.969254	0.00275836
Incompleted	Green	1.39291	0.121332	1.70896	10.25	2.58703	0.531196	0.955148	0.00085723
Succeeded	Cyan	1.48198	0.12025	0.9575	10.2	3.03159	0.376022	0.975372	0.00149677
Succeeded	Blue	0.517738	0.185727	0.524205	29.5604	2.85804	0.536123	0.967197	0.00106937



APPLICATION OF THE MODEL





- Structural simulation under a 40G acceleration pulse according to FSG rules
- Maximum calculated stress inside the cell reaches approximately 1,1 MPa
- High safety margin confirming structural integrity under regulatory load conditions