



SGL GROUP
THE CARBON COMPANY

Classical and Future Applications of Carbon Material

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SGL Group, Technology & Innovation

ANSYS Conference & 31. CADFEM Users Meeting 2013

BROAD BASE. BEST SOLUTIONS.

Outline

Company Profile - SGL Group

Unique Properties of Carbon Material

Parametric Design Optimization at SGL Group

Classical Graphite - Electrodes for Electric-Arc-Furnace

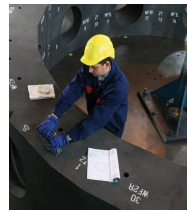
Future C-Fiber Reinforced CNG-Tank for Automotive Application

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SGL Group

Key Figures

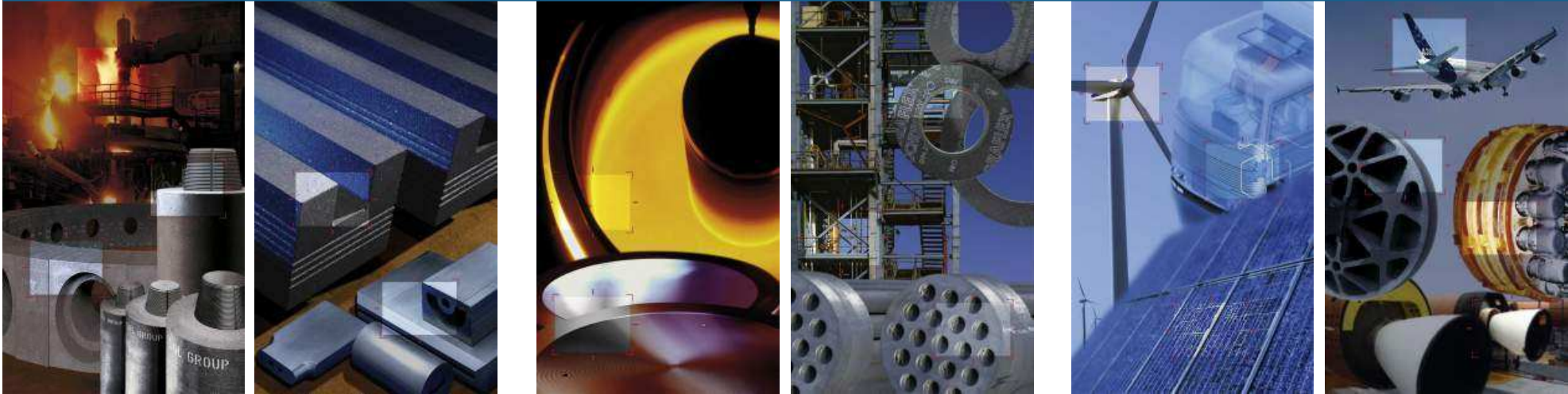


- **SGL Group is one of the world's largest manufacturers of carbon-based products**
- **Comprehensive portfolio ranging from carbon and graphite products to carbon fibers and composites**
- **47 production sites worldwide**
- **Service network covering more than 100 countries**
- **Sales of ~€ 1.7 bn in 2012**
- **Head office in Wiesbaden/Germany**
- **Approx. 6,700 employees worldwide**
- **Listed on MDAX**

SGL Group

Broad Base – Best Solutions

Our markets



- **Iron and Steel**
- **Aluminium**

- **Semiconductor**
- **High Temperature Technology**
- **Automotive**
- **Chemicals**

- **Energy and Environmental Technology**
- **High-Performance Sports**
- **Aerospace**

Introduction

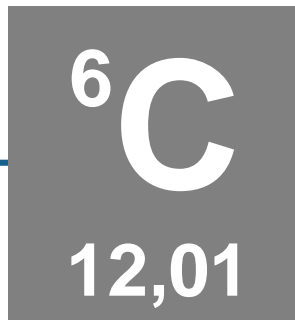
Unique Properties of Carbon

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Unique Properties of Carbon Material

Introduction

Unique Properties of Carbon



Synthetic carbon & graphite



Heat resistant
Electrically conductive
Corrosion resistant
Environmentally safe

Natural graphite



Thermally conductive
Dense
Energy storing

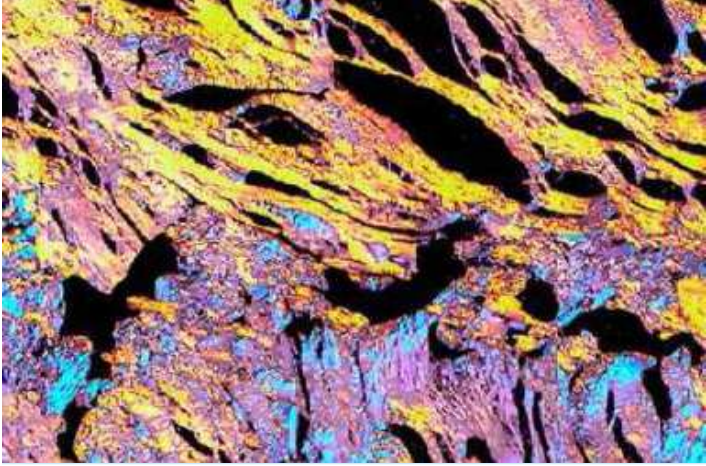
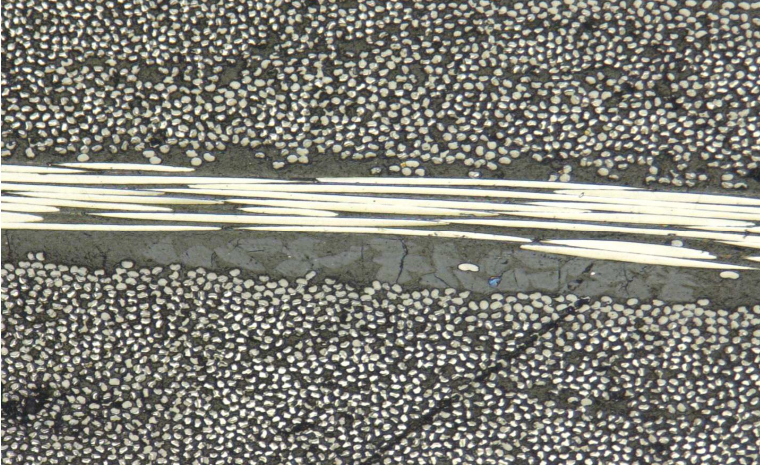
Carbon fiber



Light weight
Strong
Stiff

Introduction

Graphite vs. C-Fiber-Reinforced Plastic (CFRP)

	Graphite	CFRP
Image of Microstructure		
Filler	Anisotropic Coke Grains	Anisotropic Carbon Fibers
Matrix	Carbonized Pitch	Cured Resin
Impregnation	Pitch	None

Parametric Design Optimization

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Classical Graphite Application

Graphite Electrodes for Electric-Arc-Furnaces (EAF)



Steel-scrap is recycled by melting with an electric-arc



SGL graphite electrodes feed melting-current into the electric-arc

Electrodes for Electric-Arc Furnaces

Challenges and Impact of Modelling

High power graphite electrodes

- High demand on product due to temperatures $> 1500\text{ °C}$
- Productivity in steel-plant reduced by broken electrodes (1 M\$/day)

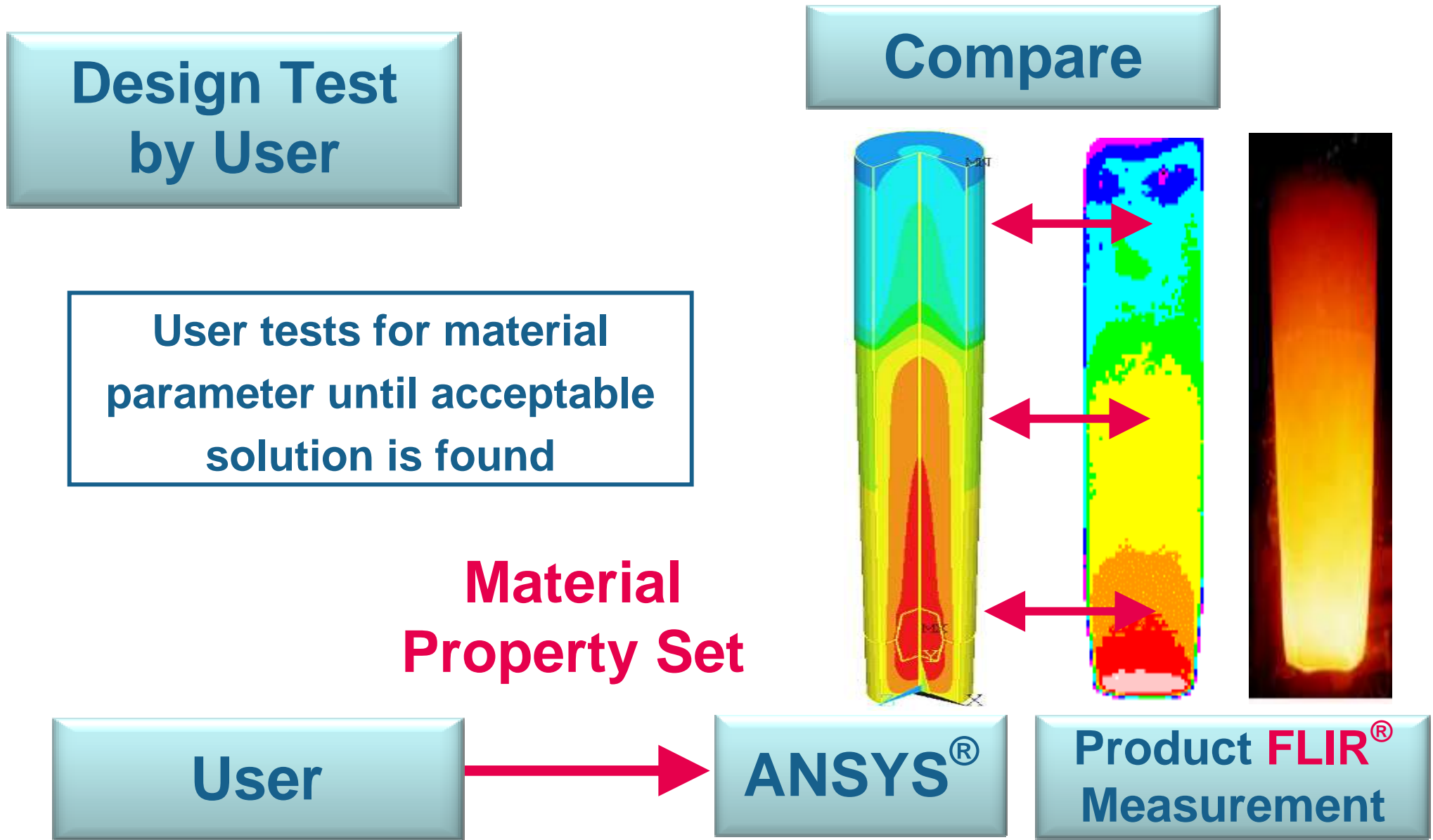
Importance of modelling

- Inverse simulation to calibrate model at application temperatures
- Enable fast design iterations for best product



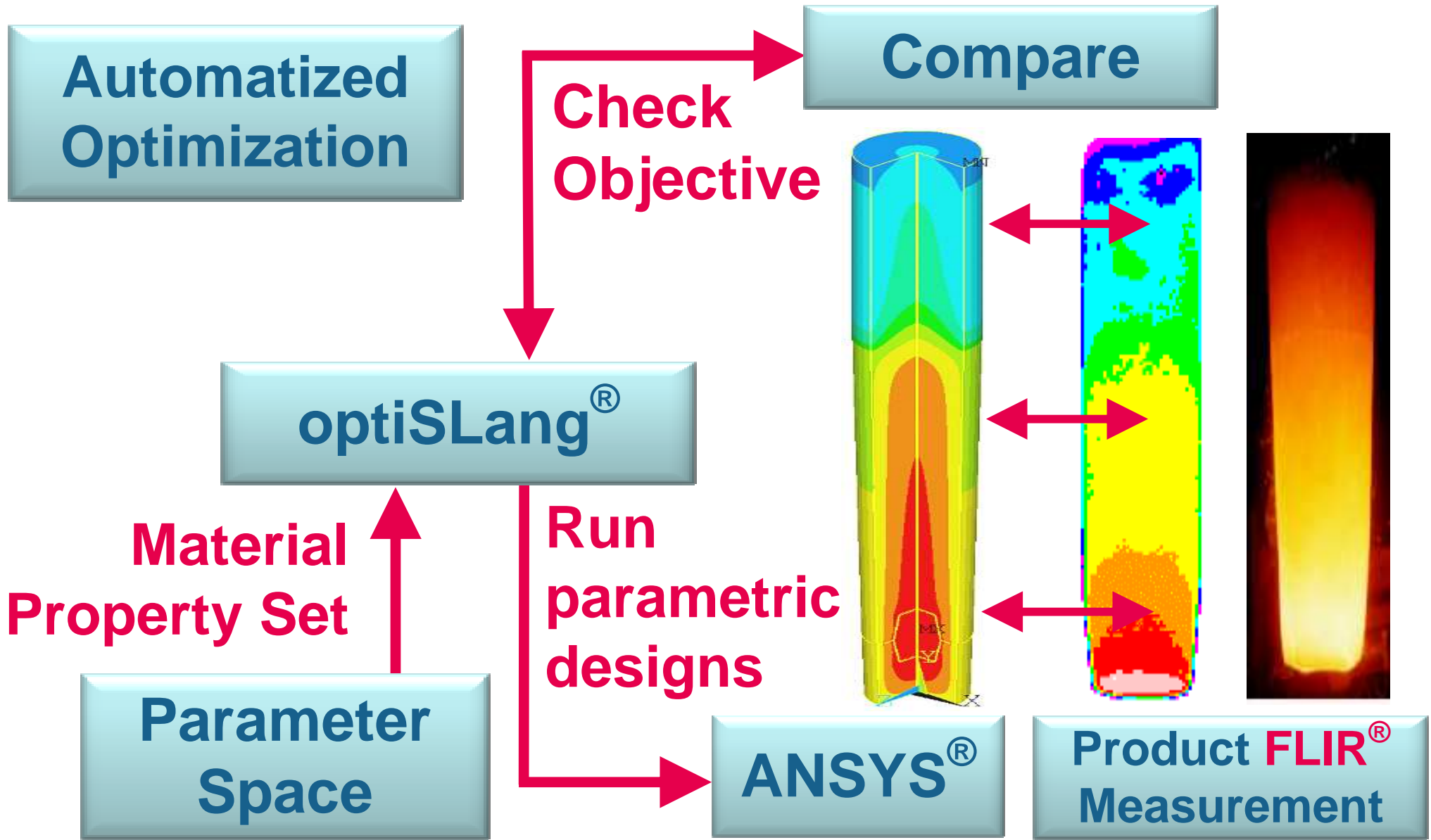
Inverse Simulation for Model Calibration

Testing of Single Designs



Inverse Simulation for Model Calibration

Parametric Design Optimization



Inverse Simulation for Model Calibration

Parametric Design Optimization

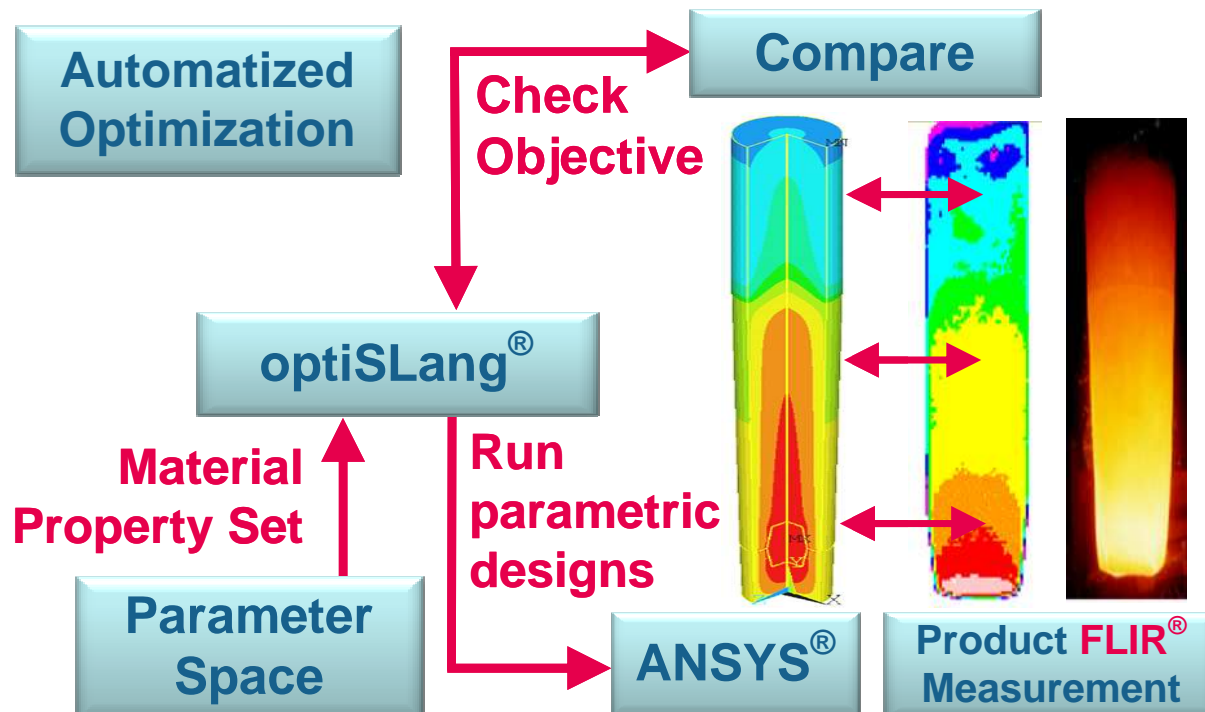
Automatized Optimization

1. Fast Iterations

Intelligent
Automatization

2. Robustness

Test complete
parameter space



3. Cost-saving

Efficient license-use (over-night)

Reduced staff (automatized optimizer)

Virtual Field-Testing of Electrodes

Robust Design Optimization

Possible Designs

Design Plan

- Adjust product to specific conditions in application

Select best designs

Avoid bad designs

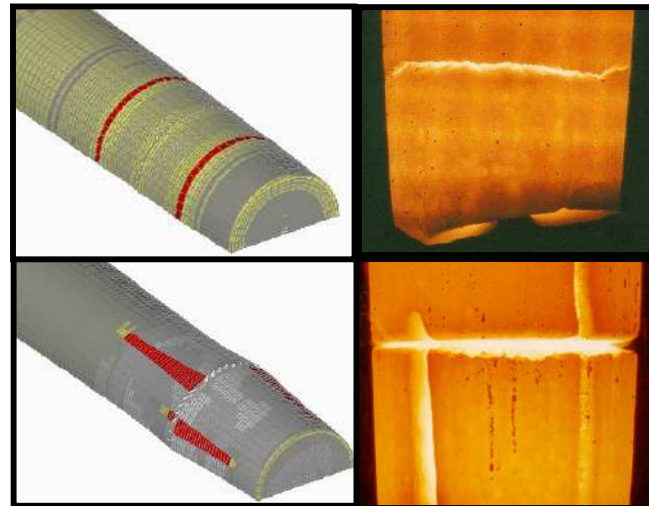
- Reduce costs for field-tests
- Fast iterations in development

Predict behavior in application

ANSYS®

Avoid

Select



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C-Fiber based Applications

CNG-Tank for Automotive



C-Fiber reinforced steel-vessel



<http://www.luxfercylinders.com/products/cng/specifications> [18.12.2009]

CNG Tank

Compressed Natural Gas
for automotive application

Model-driven Product Development

Application- & Production-oriented Optimization

Questions to modelling in design phase:

- Effect of winding-patterns on properties
- Feasibility of chosen winding for production

Requirements of application & production considered early by modelling

Winding-Pattern



Steel-vessel reinforced by CFRP winding

Model-driven Product Development

Application- & Production-oriented Optimization

FE-Model at Field-Conditions

- Cyclic load by charge and discharge processes
- Lifetime limited by strain increase by cycles

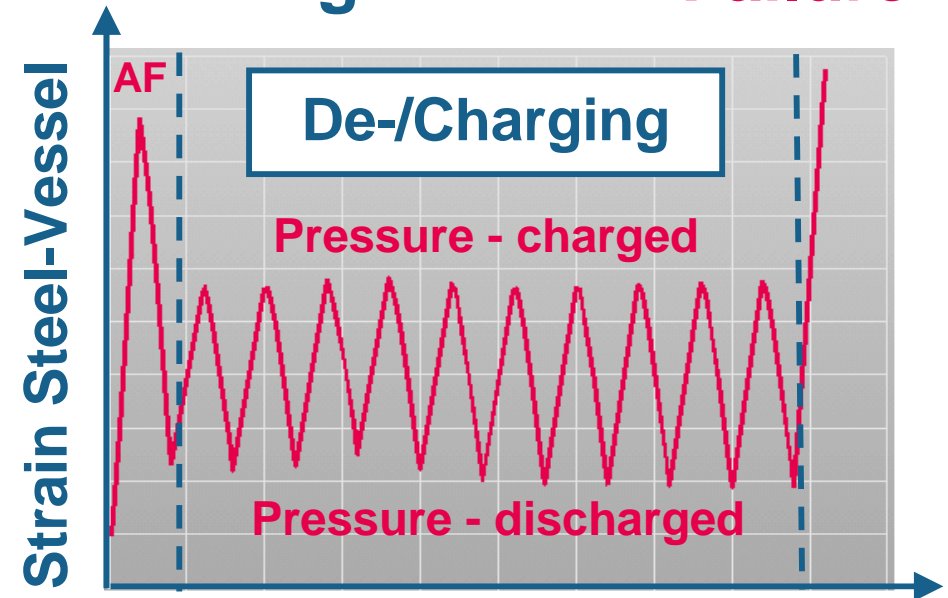
Best arrangement of fiber-layers found for critical application conditions

Pressure-Distribution after Auto-Fretting



Auto-Fretting

Failure



Loading Cycles

Model-driven Product Development

Find Best Solution by Parametric Optimization

Competitive Advantage by Parametric Designs

Save Money !

- Less expensive field tests required
- More efficient license use

Increase Development Speed !

- Short response times in development
- Fast iterations during design phase
- Identification of safe design for all possibilities

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