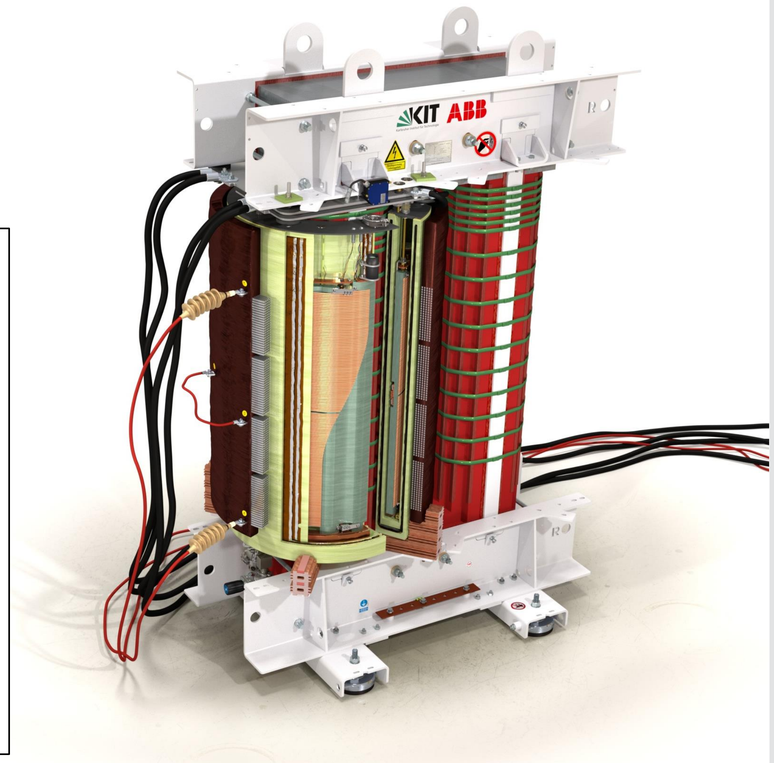
Karlsruhe Institute of Technology

Poster-ID: 3LP6-12
EUCAS 2017, Geneva, Switzerland

AC-Loss Measurements and Detailed Loss Analysis on a 1 MVA – Class Superconducting Fault Current Limiting Transformer

Authors: S. Hellmann[1], M. Abplanalp[2], M. Noe[1]



Transformer Specifications

- Transformer primarily designed for current limitation
- Conventional transformer parts except superconducting secondary winding and surrounding cryostat
- Primary winding and iron core are operated at room temperature
- Secondary winding cooled with LN_2 at 77.3 K in open pool boiling cryostat
- Secondary winding is composed of 12 parallel, 4 mm wide YBCO-tapes

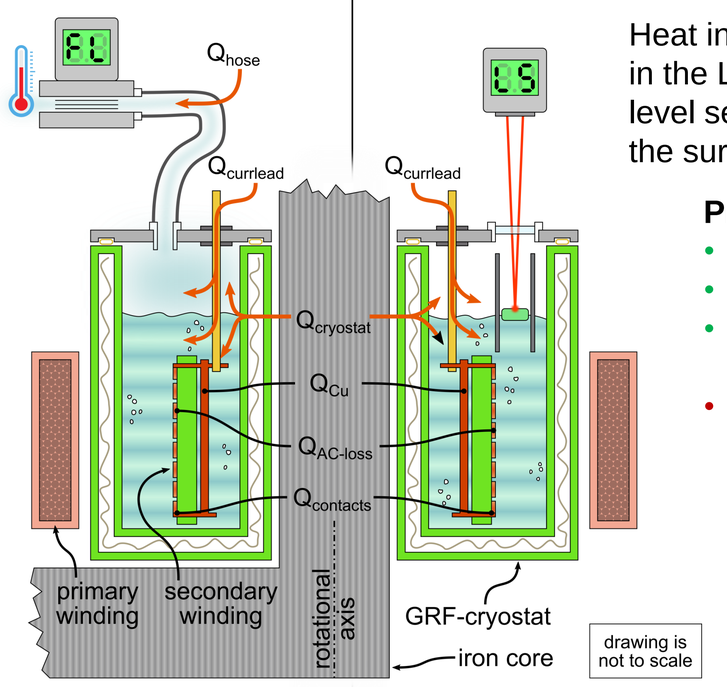
Name	Unit symbol	Value	Unit
nominal power (single phase)	P_{nom}	577	kVA
prim. voltage / sec. voltage	U_{prim} / U_{sec}	20 / 1	kV
prim. current / sec. current	I_{prim} / I_{sec}	28.9 / 577.4	A
prim. turns / sec. turns	N_{prim} / N_{sec}	500 / 25	-
critical current sec. winding	$I_{c,sec}$	1680 (avg.)	A
grid frequency	f_{grid}	50	Hz
short-circuit impedance	u_k	2.98	%
fault duration for current limitation	t_{fault}	60	ms

Mass Flow Analysis - Methodology

Evaporation of LN_2 inside the cryostat is determined by measuring the mass flow of N_2 gas leaving the cryostat, via a mass flow meter

Pros / Cons

- **Precise measurement possible**
- **Requires gas tight cryostat**
- **Unknown Q_{hose} makes calibration necessary**

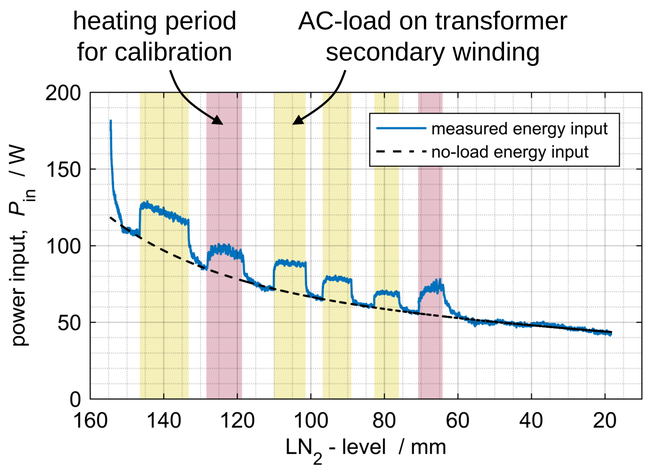


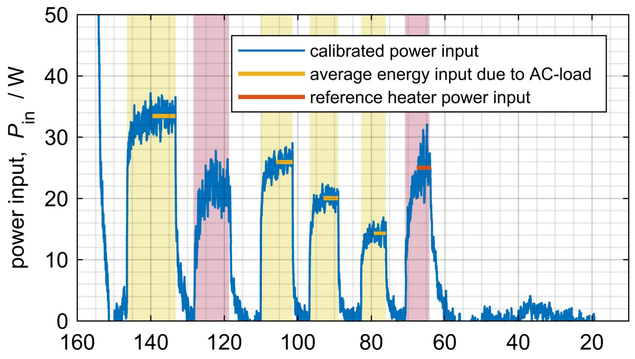
LN_2 Laser Level Analysis - Methodology

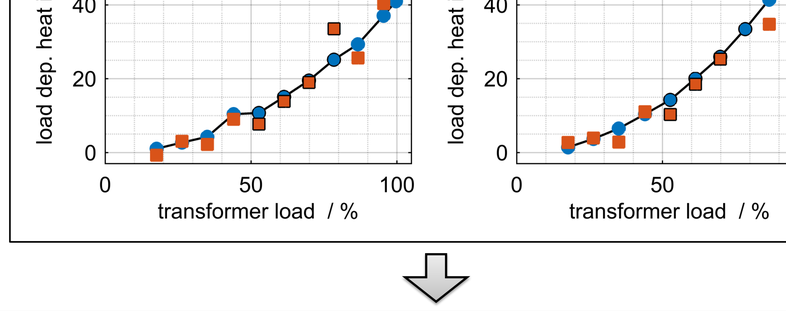
Heat intake into the cryostat is calculated from the changes in the LN_2 filling level. The level is determined via a laser level sensor measuring the distance to a styrofoam floater on the surface of the LN_2 reservoir inside the cryostat

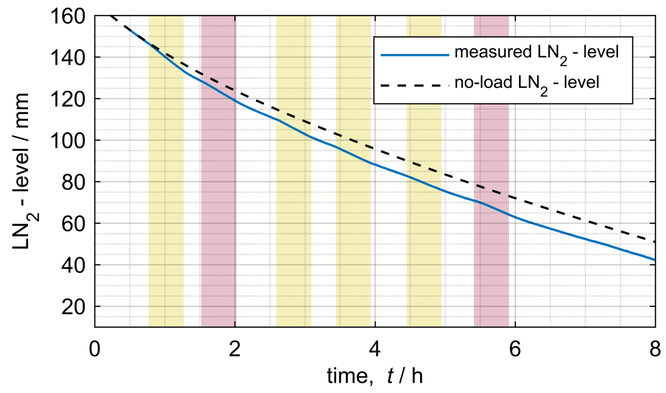
Pros / Cons

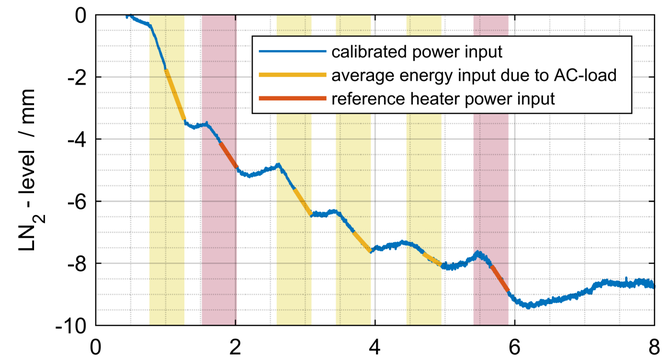
- **No gas tight cryostat needed**
- **No lid on cryostat required**
- **Laser sensor can be far away from any high electric- or magnetic fields**
- **Sensitive to thermal contractions in measurement setup**





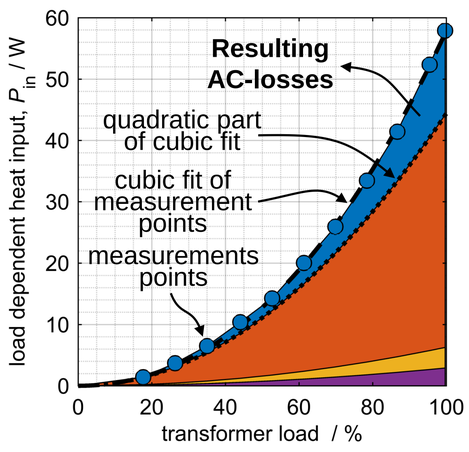






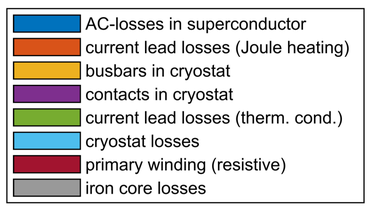
Results

1-phase – load dependent heat input in cryostat

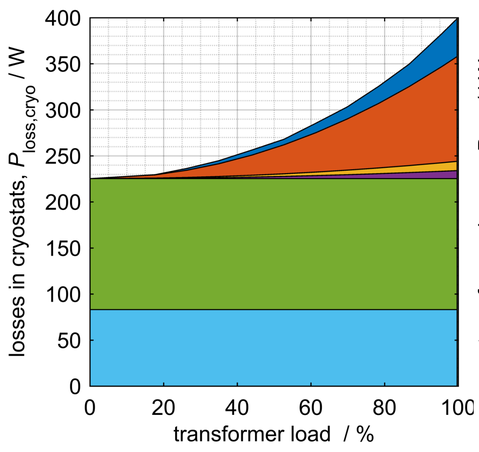


1-phase → 3-phase conversion:

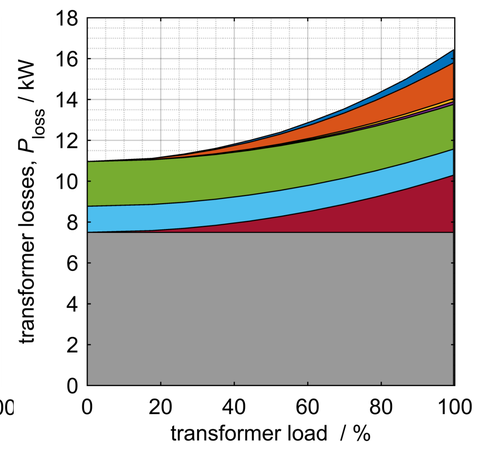
- three separate coil pairs in separate cryostats
- common iron core (4216 kg → 7418 kg)
- $\eta_{cooling}$ = 6.5%



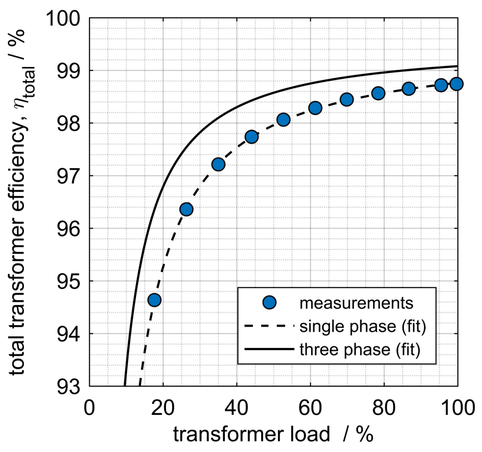
3-phase – losses in cryogenic environment



3-phase– total transformer losses



1-phase and 3-phase – total efficiency



([1] Karlsruhe Institute of Technology, Eggenstein-Leopoldshafen, Germany; [2] ABB Corporate Research Center, Dättwil, Switzerland)