Paris Session 2022

Experience with alternative transformer technologies

SC A2 Power Transformers & Reactors

PS2, Q2.5 - There seem to be conflicting opinions concerning the use of some alternative transformer technologies at higher temperatures, especially ester-immersed transformers. What is the experience of using alternative transformer technologies at higher temperatures? What further work is needed on this subject?

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Group Discussion Meeting

Summary

- There is a good record of experience at the industry with various applications of transformers designed for higher temperature operation.
- These transformers historically used various types of alternative liquids, incl. esters. Today, developments continue on new types of advanced liquids.
- Continued research is needed for adopting the new liquid solutions but comprehensive evaluation of insulation systems.
- New solid insulation components are also under development for matching the increasing temperatures allowed by new insulating liquids.

Experience of using alternative transformer technologies

- The longest record of experience with transformers designed for high temp operation is with traction on board transformers.
- Technology evolved to high temp applications with hybrid insulation systems and mineral oil, then for high temp solutions with esters.
- Use of high temp systems with low-flammable, environmentally sustainable liquids, as recognized by IEC 60076-14 can provide reliable solutions for:
  - unpredictable energy peak demands,
  - weight and dimension limits for fast-deployable power transformers and for smaller transformers for renewable energy or industrial applications,
  - fire accidents,
  - transformer life extension.
- Overloadable resilient area station power transformers (AST*) with esters have been implemented several years ago in US, with no concerns observed for their operation.

**AST - typically medium power transformers to transform the transmission line voltage (e.g. 132 kV) to a local area distribution network voltage (e.g. 11 to 33 kV); power rating in the range of 10 to 93 MVA*

Historical data for Japanese traction on-board high temp transformers after 12 years of service, showing minimal degradation of aramid insulation.

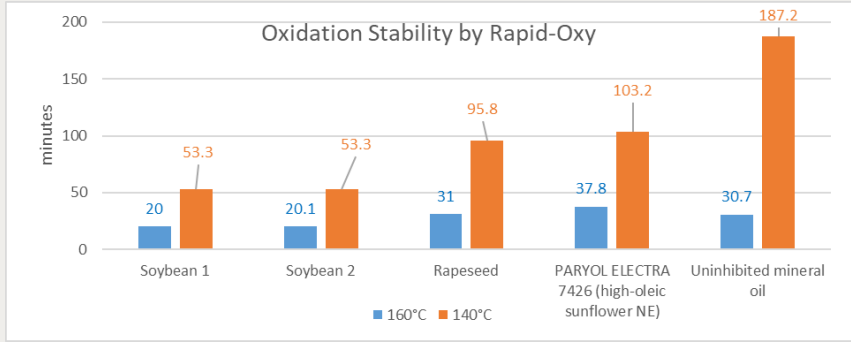
Transformer Company	Transformer sample name	Wire sampling position	Tensile strength (N/cm)	Retention of Ts (%)	Service mileage (km)
A	A1	B	37.02	94.40	4,323,977.4
B	B1	B	33.01	84.10	3,962,719.4
	B2	C	37.08	94.50	4,491,892.8
C	C1	E	37.29	95.10	4,491,892.8
	C2	E	32.00	81.60	4,491,892.8
D	D1	A	34.79	88.70	4,323,977.4
	D2	A	34.63	88.30	4,323,977.4

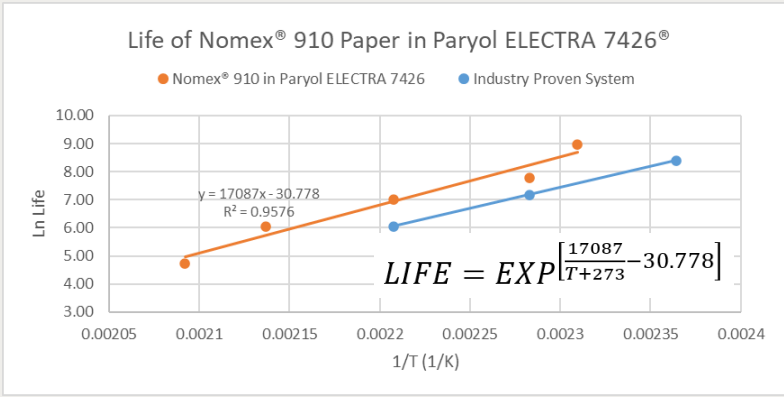
Compact area station transformer (AST) with synthetic ester

photo: Siemens Energy

Further steps

- Application developments with high temperature insulation systems continues for
  - Overloadable resilient power transformers
  - Large wind turbine transformers
  - Power transformers for offshore installations (floating or submersible)
- Material research focuses on:
  - Detailed analysis of functional properties of ester liquids,
  - Detailed thermal evaluations of insulation systems with specific combinations of insulation materials and liquids (supported by 3rd party independent certifications),
  - Development of state-of-the-art aramid-based insulation components to compose entire insulation structure of high voltage power transformers,
  - Developing characterization methods for proper thermal evaluation of insulating liquids.





Aramid based components for new advanced insulation systems
(photo courtesy of Schweizer and Isotek)