NAME : Anastasia O'Malley
COUNTRY : USA
REGISTRATION NUMBER :

GROUP REF. : A2
PREF. SUBJECT : 2
QUESTION N° : 5

Innovative Resilient Transformers

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?

Anastasia O'MALLEY
Consolidated Edison Co. of NY, USA

Radoslaw SZEWCZYK, Jean-Claude DUART
DuPont, Poland, Switzerland

Kurt KAINEDER, Robert MAYER, Ewald SCHWEIGER
Siemens Energy, Austria, Germany

Our input is based on our papers A2 11022 2022, D1 302 2021 and other transformer experiences which use technologies for higher temperatures.

- **Motivation**
  - Decarbonization is leading to electrification of transportation and heating sectors resulting in changing load profile and load growth
  - In addition, climate change forecasting increased ambient temperatures
  - Utilities have the same, if not worse, space constraints
  - Need for improved resilience of the electric grid
  - Alternative technology using ester immersed transformer with high temperature insulation components presents an innovative solution

- **Challenges for operating at higher temperatures**
  - Limitation of traditional material (e.g. insulation) and components
  - Calculation and design tools need to be adapted considering new materials and combinations

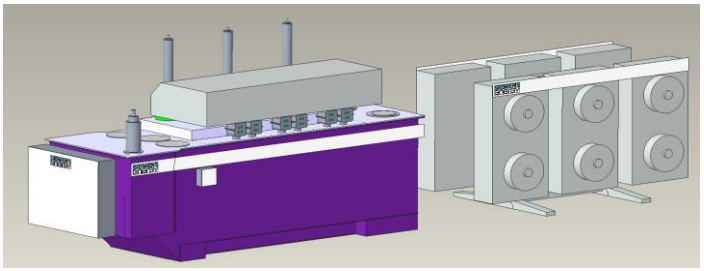
- **Approach to be chosen**
  - New technologies and materials undergo upfront testing to ensure compatibility in the transformer
  - Design tools updating and verification via tests of transformers of various sizes,
  - Sophisticated electrical and mechanical tool landscape capable of optimizing the transformer design within the given constraints

- **Solutions applied in transformers**

- Use of aramid material for insulation components (e.g. cylinders and end-insulation structure like stress rings, molded caps, collars, snouts, spacer blocks or clamping plates.)
- Hybrid insulation systems (combination of newly developed materials and solutions with traditional ones)

- **Achievements** (case study A2 11022 2022)
  - Achieve maximum operating flexibility with a fast-deployable, lighter-weight unit that would fit in an existing tight substation space.
    Applying the plug-and-play features like plugin bushings and cables for shortest possible installation time of these grid resilience units. Fast deployment (less than a week) for emergencies,
  - Two high-voltage levels (132 and 65 kV), three low-voltage levels (13.8, 28 and 35 kV) in combination with low-voltage LTC and a narrow impedance band requiring up to eight individual windings per phase,
  - DETC accommodating the changeover of voltage levels and avoiding handling of liquid during deployment. Design including four DETCs and one OLTC
  - Power rating up to 93 MVA and high overload capacity of up to 200% ,
  - Highly efficient routing of the lead structure essential to accommodate the heating effects from stray flux
  - Quiet operation - Stringent noise requirements and complex winding geometry requiring a massive core of low-noise, grain-oriented magnetic steel grade, with cooling ducts of a high-thermal class material,
  - Maximum transport weight of 200 000 lbs. (91 t) , Substations with tight spaces and difficult access ,
  - Filled with synthetic ester liquid.

- **References** (excerpts)
  - Further case studies in papers A2 11022 2022 and D1 302 2021
  - Single phase multi ratio resilience GSU, each 83.3MVA, total weight 97 tons
  - 93 MVA transformers 132 kV – in service since 2022
  - 65 MVA transformers 132 kV – in service since 2018
  - 58 MVA transformers 65 kV – planned service 2023



-

Assembled single phase multi ratio resilience GSU transformers 250 MVA (Voltage range: HV 115-400kV, LV 12-34,5kV) (photo: Siemens Energy)

Compact area station transformers Type 2: Synthetic ester liquid Midel® 7131 (photo: Siemens Energy)

- **Further work**
  - Investigations and upgrading of materials/components (e.g. OLTC, bushings, accessories)
  - Longer term / aging investigation for very high temperatures
  - Updated thermal models for utility transformer rating calculations
  - On going development of full aramid insulation system for transformer active part
  - Educating regulatory agencies