Study Committee A2

Power transformers and reactors

11140

Analysis of new dielectric fluid alternatives using the design of a thermal distribution test platform model and CFD methods

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Introduction

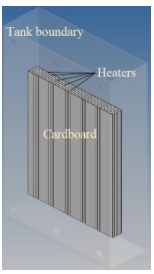
This work presents results obtained by CFD analyses of different fluids (natural ester and mineral oil) in a test platform designed to emulate the thermo-hydraulic behavior of a 100MVA real power transformer. The aim is validating the original model in its application to a 2D simplification studying a new alternative to the traditional cooling liquid.

Motivation

- Background:
  - Power transformers do not have realistic mid-term alternatives.
  - Traditional mineral oil has limits (flammability) and drawbacks (not environmentally friendly) as cooling main part of power transformers.
  - Natural esters, synthetic esters and gases can be developed in cooling applications.
- Aim of the study with the development of a test platform:
  - To create a cheaper way to analyze thermal behavior.
  - To have an adaptive tool to study different transformers .

Methodology

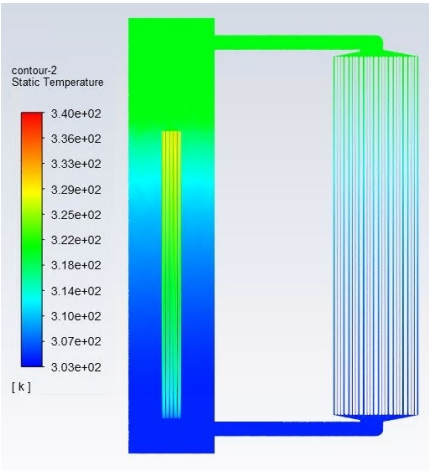
- Design the test platform in 2D.
  - 5 heaters
  - 2 cardboards
  - Tank
  - Radiator
  - Connection pipes



- Assignment of different fluids to the model for each simulation.
- Analysis considering laminar flows and ONAN operation regime in a close-loop of cooling. Simulations carried out using Ansys Fluent 2020R1.
- Comparison between the results of liquids to determine the viability of natural ester for the case.
- Repeating the process for 1.15pu overrated conditions.

Test results

CFD analysis with the real design size applied to 2D and considering heater depth reference and rated operation in ONAN regime.



Model	Hot-spot temperature
Mineral oil Rated Power	51ºC
Natural ester Rated power	61ºC
Mineral oil 1.15 pu overrated (figure)	57ºC
Natural ester 1.15 pu overrated	67ºC

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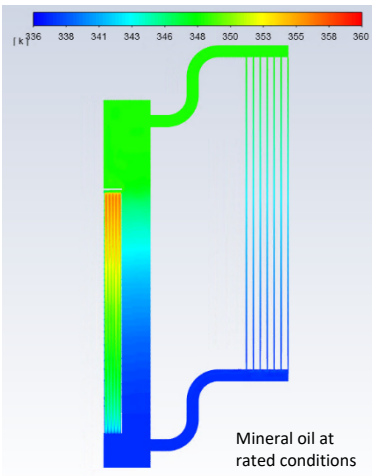
Discussion

- Temperatures are lower than expectations.
- Overcooling has happened.
- Validation with real transformer is not possible to be confirmed.
- Mineral oil is better than natural ester for all the cases studied.
- For overrated conditions at 1.15 pu, the HST is also reduced in the case of mineral oil. However, the relative HST increase (which occurs comparing the two loads) is higher with this fluid, indicating possible better responses of natural ester at high loads.
- There are no problems in simulation but there are design adaptation problems to 2D model.

In addition

- 2D models can be enough to simulate this type of design with adaptive changes.
- Temperature results can be validated with the real transformer values obtained from fiber optic sensors and thermal images during its operation.
- The study has been useful for adaptation model giving support to the general 3D design.



Mineral oil at rated conditions

Conclusion

- For low loads, mineral oil is better than the natural ester analyzed.
- Adaptation from 3D model to 2D model is necessary. Otherwise, problems with validation and reliability can occur.
- One solution for overcooling is resizing radiator part of the transformer or test platform.

Acknowledgements

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