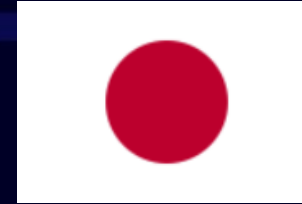


Paris Session 2022



Bubble generation temperature evaluation of ester-immersed transformer windings

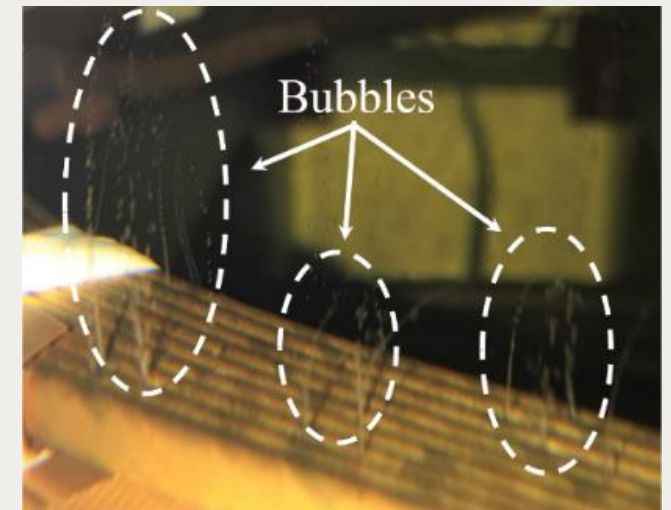
SC A2 PS2 Question 2.5

Kiyoshi WAKIMOTO (Japan)



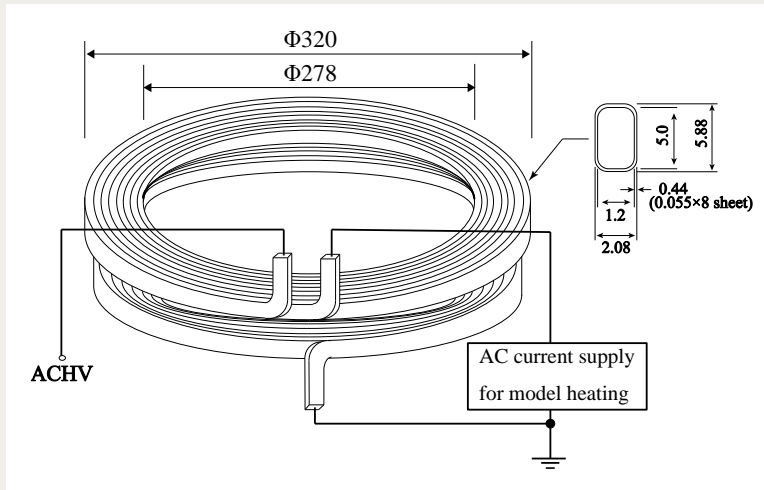
Introduction

- Synthetic esters, **natural esters (vegetable oils)**, and more recently **modified esters derived from vegetable oils** have all been developed as alternatives to mineral oil. In particular, vegetable oils have contributed to reducing carbon dioxide emissions.
- **Transformers using vegetable oils (esters)** are applied for renewable energy such as solar power and wind power to achieve carbon neutrality, and **the oil deterioration prevention structure may be a nitrogen-sealed type**, not a conservator type.
- **The risks of a transformer due to overloading** can be classified into two categories: (a) reduced mechanical strength of the insulation paper in the transformer winding due to accelerated thermal aging and (b) **reduced insulation property due to bubble generation caused by heat produced in the transformer winding.**



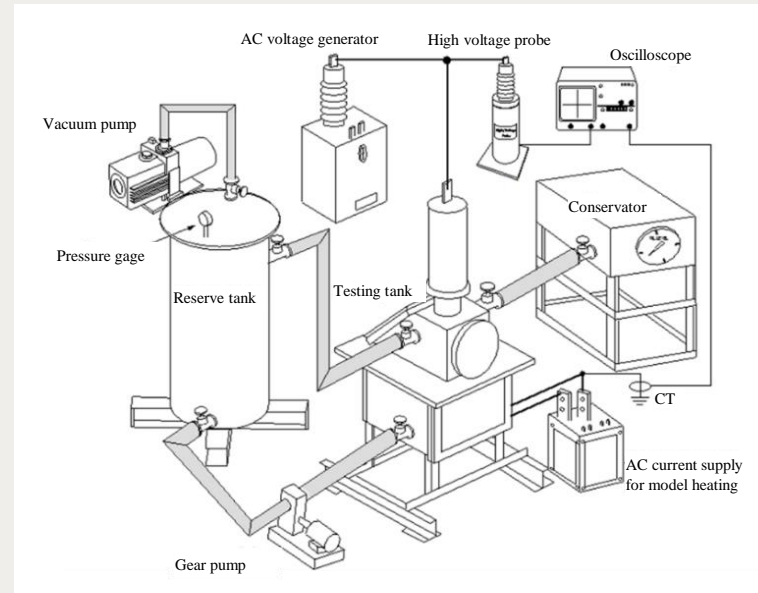
Bubble generation temperature

The bubble generation characteristics of two esters (FR3 and Pastell NEO) with almost the same saturated water content and different kinematic viscosities were investigated using a winding model simulating the steep overload of a transformer.



Winding model for bubble generation.

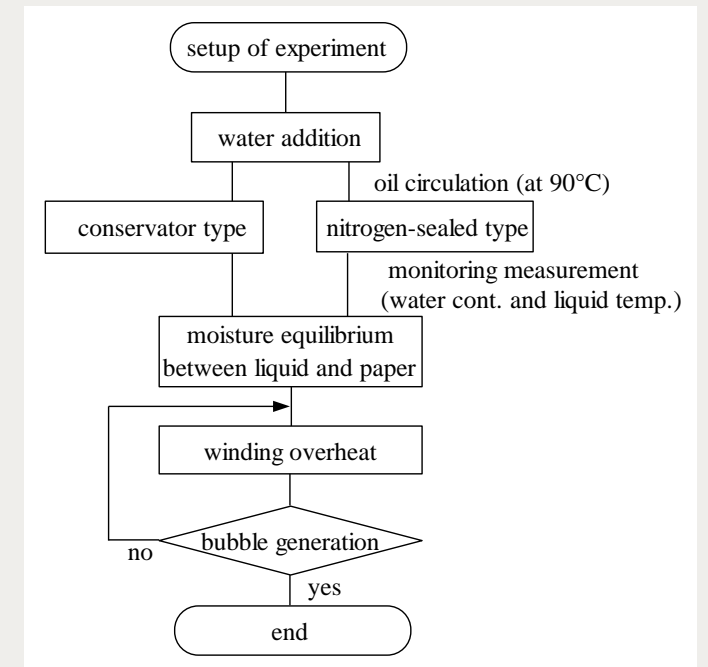
Group Discussion Meeting



Outline of experimental system.

Principal properties of insulating oils.

Property	Mineral oil	FR3	Pastell NEO
Density at 20 °C (kg/m ³)	880	920	860
Viscosity at 40 °C (mm ² /s)	8.8	32	5.1
Water solubility at 25 °C (ppm)	70	1100	1000
Solubility of N ₂ at 90 °C (vol %)	10.3	9.3	---
Surface tension (N/m)	0.030	0.024	---



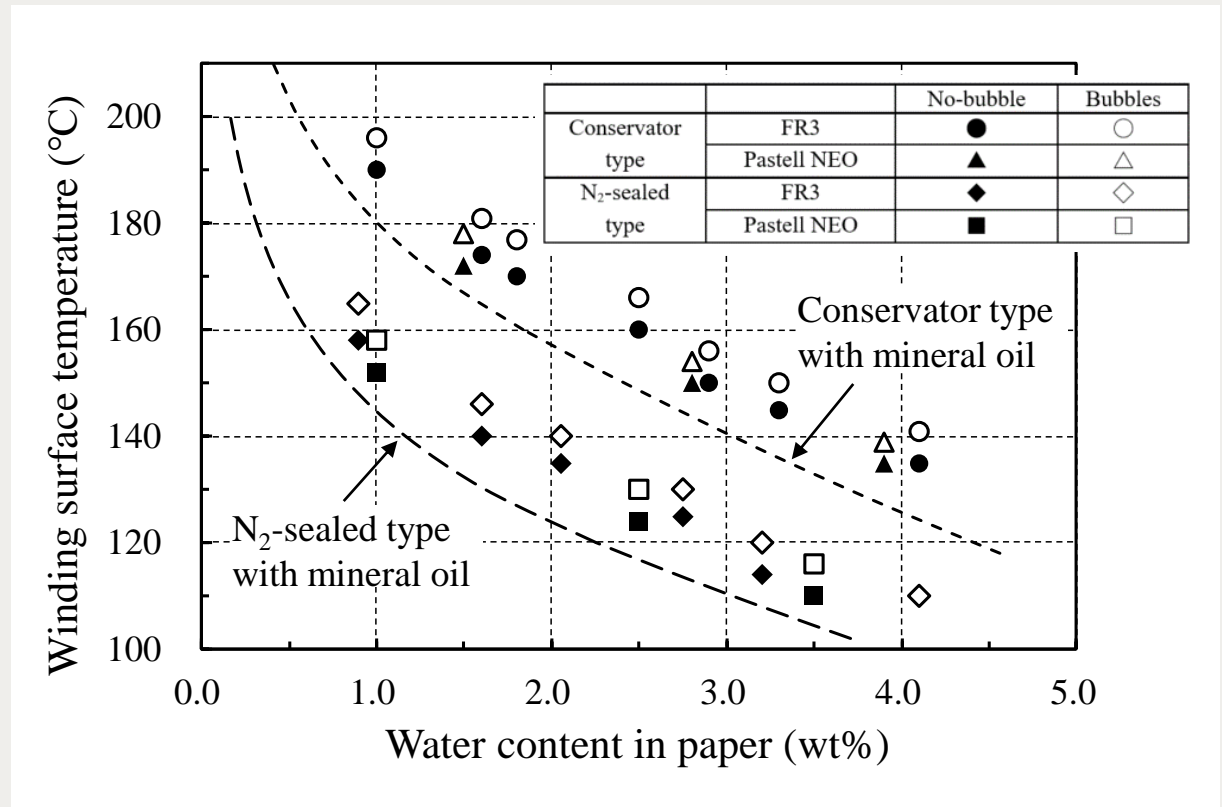
Overview flowchart of experimental procedure.

As a result, experiments using both conservator and nitrogen-sealed type winding models to simulate the oil deterioration prevention structure showed that with similar water content in the insulation paper, **the bubble generation temperature was higher with conservator than with nitrogen-sealed type.**

Conclusion

If the oil deterioration prevention structure is a **nitrogen-sealed type** then caution might be necessary because **the bubble generation temperature is lower** than in the case of a conservator type, in using esters in high temperature designs, as in the case of a mineral oil.

Group Discussion Meeting



Comparison of esters to mineral oil results.

FR3 is a registered trademark of Cargill, Incorporated.
Pastell NEO is a registered trademark of Lion Specialty Chemicals Co., Ltd.