NAME : Kazuhiro SHIBATA
COUNTRY : JAPAN
REGISTRATION NUMBER : DLG6974
GROUP REF. : SC A2
PREF. SUBJECT : PS2
QUESTION N° : Question 2.5

Question 2.5 :
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 ?

Installation of rapeseed oil transformers for environmentally benign substation

Kazuhiro SHIBATA (kansai Transmittion and Distribution, Inc.)

1. Summary

Kansai Transmission and Distribution, Inc. is planning a new substation (E-SSS : Ecological-smart substation) for environmentally benign substation that uses SF6 alternative gas for swichgear and vegetable oil for transformers, as well as AI and IoT devices for equipment condition monitoring, patrol and inspection. As part of this plan, five natural ester (rapeseed oil) immersed transformers will be installed in a new substation scheduled to start operation in 2023, and the characteristics of these transformers will be introduced.

2. Characteristics of Rapeseed Oil Transformer

Natural esters are flame retardance, biodegradability, high water absorption, and high kinematic viscosity (Table 1). The operational performance of rapeseed oil and soy oil, which are natural esters, is equivalent and soy oil is the predominant oil worldwide. Rapeseed oil was chosen because it is less expensive than soy oil and can be produced in Japan.
Characteristics of rapeseed oil are as follows.

1) Flash point (COC) is 322ºC that makes it possible to treat it as a designated flammable material (250ºC or higher) in Japanese fire regulations. Thus, an application for provisional handling of hazardous materials is no longer required, and simplification of fire extinguishing equipment can be expected.
2) High biodegradability (89%) reduces environmental risk in case of oil leakage.
3) The saturated water content is about 10 times that of mineral oil and rapeseed oil easily absorbs the water in the insulating paper, which has the effect of suppressing the deterioration of the insulating paper. Therefore, a service life equivalent or longer than that of mineral oil transformers can be expected even at higher operating temperatures. Also, even if the water content in the oil increases, the breakdown voltage is difficult to decrease (Figure 1, 2).
4) Rapeseed oil, absorbing CO2 during the growth process of rape blossoms, is carbon neutral materials that do not result in increased CO2 emissions. CO2 emissions from raw material production to incineration treatment are about 1/6 of mineral oil.
5) Care should be taken due to high water absorption and kinematic viscosity.

Table 1. Properties of vegetable-derived insulating oil [1][2]

Classification		Natural Ester		Vegetable Oil Ester	Low Viscosity Silicone	Mineral Oil
Name		Rapeseed Oil	Soy Oil	Palm Fatty Acid Ester	PDMS	
Flash Point (COC)	ºC	322	330	176	260	148
Fire Point (COC)	ºC	360	360	-	-	160
Kinematic Viscosity	mm^2/s(40ºC)	35	34	5	16	8
	mm^2/s(100ºC)	8	8	2	7	2
Biodegradability	% (28 days)	89	100	77	-	0.13
Water Content	ppm	~ 1000	-	-	-	≤ 100

3. Application of Transformers with Upgraded Temperature Rise Limits

In general, the cost of the rapeseed oil is expensive than the mineral oil. As a cost reduction of the rapeseed oil transformer, there are eased criteria (oil : 70K, winding : 75K) for its temperature rise limits than Japanese Electrotechnical Committee (“JEC-2200-2014”). According to IEC 60076-14:2013, natural ester/thermally upgraded paper system can be upgraded by 20.6K in the temperature rise limits if they are expected to have the

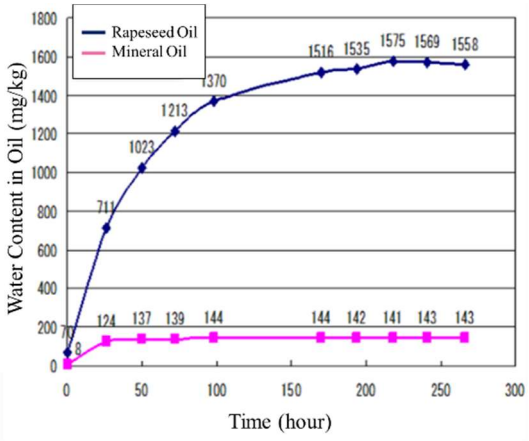

Figure 1 : Water content in oil

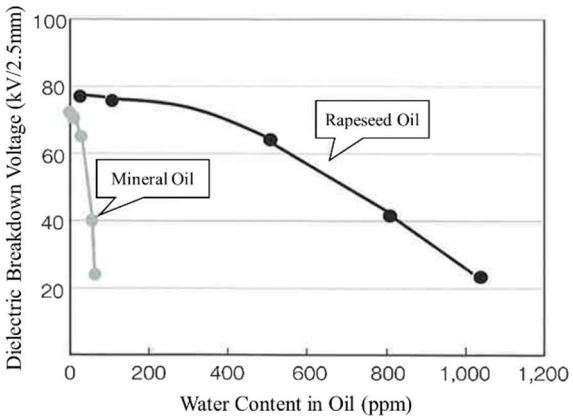

Figure 2 : Relationship between water content and breakdown voltage [2]

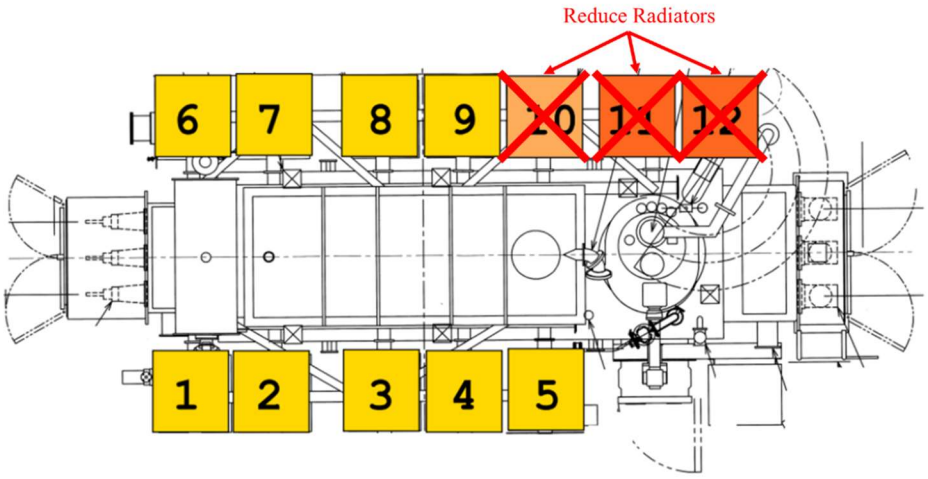

Figure 3 : Transformer radiator with upgraded temperature rise limits (18.26MVA)

same lifetime as mineral oil. The temperature rise limits of transformers were determined so that the cost of the transformer component materials would be lowest.
By upgrading the temperature rise limits, the number of radiators can be reduced and the rapeseed oil transformer downsized (Figure 3). The compactness of the rapeseed oil transformer allows it to be transported without disassembling the radiators and ducts. In addition, high efficiency (99.4%) has been achieved by optimal design.

4. Others

The structure of the rapeseed oil transformer was modified in consideration of high water absorption and high kinematic viscosity, including the use of a nitrogen-sealed conservator in the OLTC chamber and the development of an OLTC for low-temperature operation. Maintenance standards for rapeseed oil should be determined by considering the water content and kinematic viscosity.

5. Conclusion

The temperature rise limits of transformer were upgraded to reduce the cost of rapeseed oil transformers. Since natural ester oil (rapeseed oil) is more expensive than mineral oil, it is necessary to consider using an inexpensive and highly heat-resistant insulation materials in order to further upgrade the temperature rise limits.

6. Bibliography

[1] Technical report of the Inst. of Electrical Engineers of Japan, No.1478, “Recent Trend on Diversification of Functions and Properties of Transformer”, 2020
[2] Electrical site, Vol.56, “New type of transformer using vegetable-based insulating oil”, 2017