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QUESTION N° : Question 2.1

Question 2.1:
What possibilities are there for development of new transformer design concepts? In particular, what prospects are there for development of new insulation liquids with improved properties compared with existing liquids? Also, what prospects are there for development of new dry-type transformer technologies? Finally, what possibilities are there for substitution of sulphur hexafluoride by alternative gases?

SF6-free Gas Insulated Transformer using Natural Origin Gas

Naoki NOGUCHI (Toshiba Energy Systems & Solutions Corp.)

1. Concept of SF6-free Gas Insulated Transformer using Natural Origin Gas

We propose "SF6-free Gas Insulated Transformer using Natural Origin Gas(SF6-free GIT using NOG)" in which SF6 gas is replaced by a lower environmental load gas without compromising any of the three features of SF6-GIT ; (1)the only non-flammable transformer, (2) high explosion-proof performance, and (3) no risk of oil leakage.

2. Recent our research and development for SF6-free Gas Insulated Transformer

We have long researched and developed SF6-free GIT using NOG through model test and simulation shown in Fig.1 and Fig.2 as an example. As a result, we have obtained the results that as for insulation performance, a 66kV class transformer with 0.12MPa-G and a 154kV class transformer with higher gas pressure can be realized. As for cooling performance, GDAF(forced directional circulation of the gas and forced circulation of the air) is expected to keep the temperature rise within the specified value.

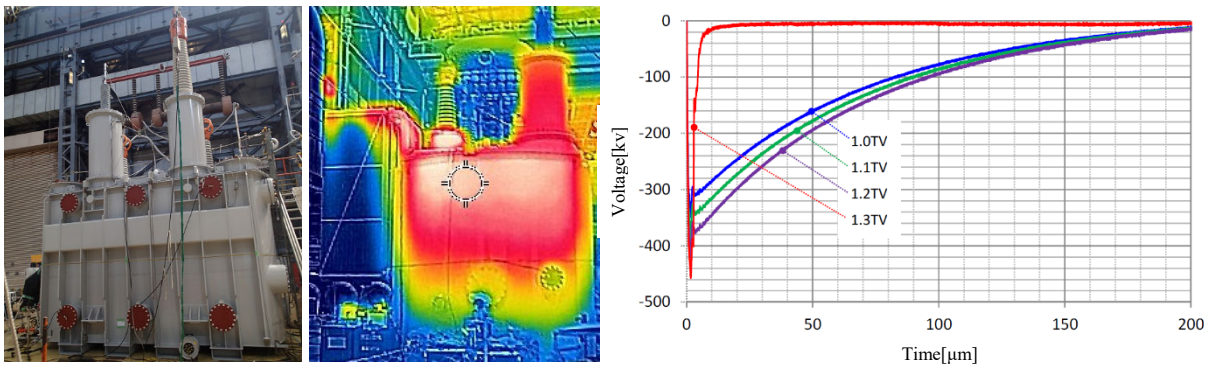

Fig.1 Test of the 0.12MPa-G Dry Air GIT($66/\sqrt{3}kV$-$15/3MVA$)
(Insulation verification passed, Self-cooling performance did not pass)

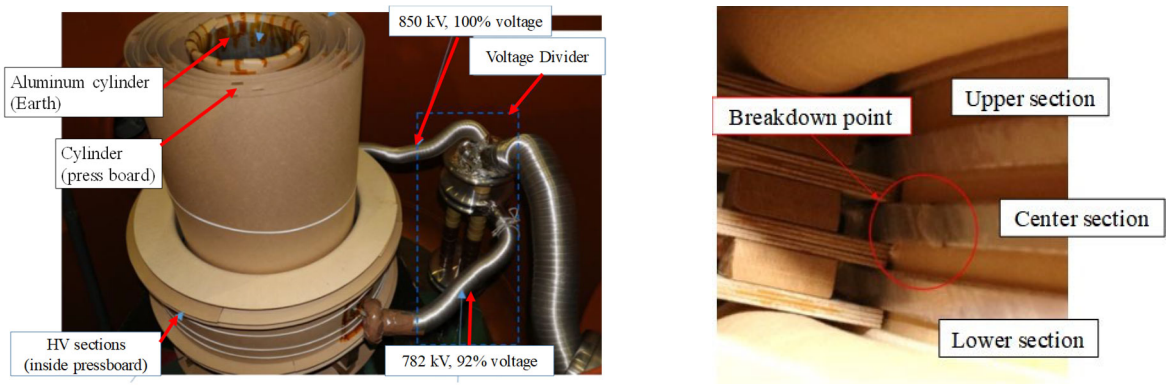

Fig.2 Test of insulation structure for 0.4MPa-G N2 GIT
(Main gap and section to section insulation model, Breakdown at 900kV LI)

3. The suitable NOG for SF6-free GIT

We have studied the most suitable gas species for SF6-free GIT using NOG. The first requirement for alternative gases is a low GWP. Other factors are stability at high temperatures and pressures, safety for the human body, and ease of handling. Taking these factors into consideration, natural origin gas, especially N2 or

CO2, are-the most suitable gases. Although the insulating and cooling performance of these gases is less than 1/3 that of SF6, it is possible to solve this problem by increasing gas pressure and other measures.

Table.1 Typical characteristics of SF6 and Natural Origin Gas

	SF6	N2	CO2	Dry Air
GWP	25200	0	1	0
Insulation Level	100%	approx. 30%	approx. 30%	approx. 30%
Heat Capacity	100%	27%	37%	approx. 27%
Stability Level of the Gas	Good	Good	Good	Bad
Safety Level of the Gas	Good	Good	Not Good	Very Good
Handling Level	Bad	Good	Not Good	Very Good

4. Desigin Study for 66kV-20MVA SF6-free GIT

The following is a comparison of SF6-free GIT and SF6 GIT at a rating of 66kV-20MVA: SF6-free GIT uses a natural origin gas that is inferior to SF6 in both insulation and cooling performance, so the size and weight of the transformer is larger than SF6 GIT, and the number of coolers required is also greater. On the other hand, SF6-free GIT has the advantages of extremely low environmental load compared to SF6 and easy installation and maintenance due to its use of natural gas. Based on these advantages, we believe that SF6-free GIT can be an option for users who need absolute safety in their transformers.

Table.2 Specification of SF6-free GIT

		SF6 GIT	SF6-free GIT
Ratings		GDAF - 50Hz - 20MVA - 64.5±7.5kV(Y) - 6.9kV(Y) - (Δ)	
Gas type		SF6 - 0.14MPa-G	N2 - 0.14MPa-G
LI test voltage[kV]	HV	350	250*
	LV	60	40*
Number of radiators		6	16
Number of gas blowers		2	4
Equipment dimensions	W	100%	105%
	L	100%	110%
	H	100%	105%
Gross weight		100%	155%

*Reduced test voltage level in Japanese standard

Fig.3 shows a conceptual drawing of an SF6-free GIT using NOG with a rating of 66kV -20MVA. We will promote the development of the SF6-free GIT using NOG, the "only non-flammable transformer with low environmental load," inheriting the best features of the SF6-GIT.

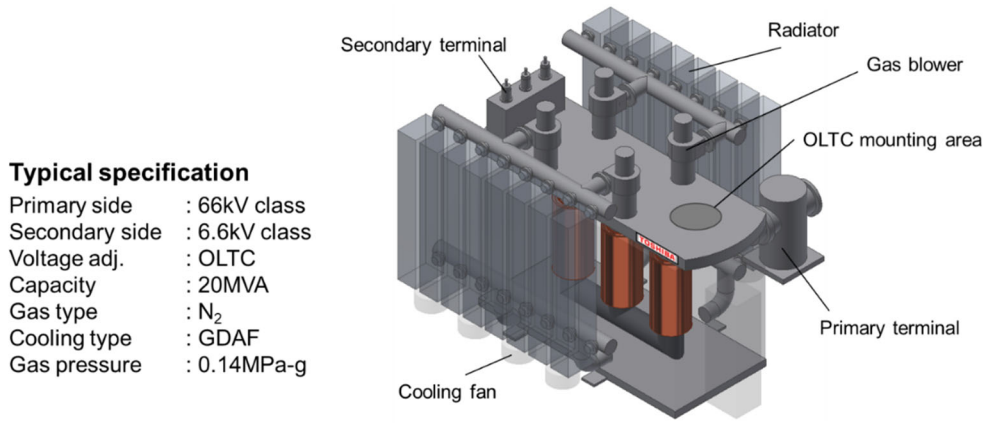

Fig.3 Conceptual drawing of SF6-free GIT (66kV/20MVA)