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QUESTION N° : 2.4

Question 2.4: Are there any applications for which alternative transformer technologies are not well suited and what can be done to develop new types of alternative transformer for these applications ?

Using alternative fluids in transformers, whose properties are different from standard mineral oil do have an impact on the design not only from thermal and dielectric point of view but also by the selection of transformer components and manufacturing process.

Table I gives a general overview on the impact of the main fluid properties once an alternative fluid is decided to be used instead of mineral one.

Table I

Property	Impact on:	Synthetic ester fluid	Bio-based hydrocarbon
		effects	
Thermal expansion	conservator	none	increase volume
Dielectric strength*)	distance between winding - lead - tank	design adaptions needed	design check, most cases no changes needed
	OLTC, DETC	reduced insulation level	none
Viscosity*)	cooling, winding	increase size of cooling ducts	none
	cooling, radiators	increase cooler surface	reduce cooler surface
Density	total weight	increase	reduce
Chemical compatibility	gaskets	limited choice of material	none
	conservator, sealing	diaphragm or N2 blanket is mandatory	none
Oil handling	degassing machine and pipes	must have dedicated system	can use existing system if flush
Component interactions	bushing	limited selection, no mixing of internally used	none
	OLTC	curent, dielectric deratings, many model restrictions	no dielectric deratings, some restrictions
	buchholz relay	order with special gaskets	most manufacterers approved

***) main players for using alternative liquids, but not the only ones.**

The investigations have shown when using bio-based hydrocarbon fluid a reduction of the cooling system by approx. 20% is possible. In order to validate the design, the max. allowed values for top liquid, average winding and hot spot temperature rise were kept the same. Two identical units were built and tested, one filled with standard mineral oil, the other filled with bio-based hydrocarbon fluid. The results in the test field had confirmed the calculations.

Table II

Design with 50 MVA-123 kV	Mineral oil (Reference)	Synthetic ester fluid	Bio-based hydrocarbon fluid	Deviation	
				Synthetic ester Fluid-Ref.	Bio-based Fluid-Ref.
Heat expansion coefficient [1/K]	0,00075	0,00078	0,00092	4,00%	22,67%
Density of insulating fluid @ 20°C [kg/m³]	0,870	0,970	0,785	11,49%	-9,77%
Viscosity @ 40°C [mm²/s]	9,30	28,00	3,80	201,08%	-59,14%
Flash point (PM) [°C]	152	260	145	71,05%	-4,61%
Oxidation test IEC_61125	500h; 120°C	164h; 120°C	500h; 120°C	-67,20%	-
Winding weight [kg]	11286	11511	11286	1,95%	0%
Weight of insulating fluid [kg]	16989	18310	14518	7,78%	-14,54%
cooler surface [m²]	552	585	423	5,99%	-23,36%
weight of conservator [kg]	680	750	780	10,29%	14,71%
Top oil rise (measured) [K] **)	48,1	-	45,0	-	-3,1 K
HS rise (measured) [K] **)	71,1	-	66,9	-	- 4,2 K

****) the designs were identical and equiped with fibre optic sensors to have a fair comparison**

Conclusion :

There is always a possibility to use alternative fluid instead of standard mineral oil, as long as operational safety and reliability requirements of are fulfilled for transformer lifetime. To overcome the challenge of dealing with new insulation fluid, the research needed must be on the base of transformer practical requirement, not a pure academic one. The right investment in research will not just lead to cost optimized design, but also a safe one.