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EFFECTS OF DC-BIAS ON HIGHLY GRAIN ORIENTED SILICON IRON

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At present, globalization of electric energy distribution is characterized by the establishment of high distance grids with increasing use of AC/DC/AC conversion. The latter yields rising relevance of direct current (DC) components that cause bias of high-voltage transformer cores. Apart from long-term bias of low intensity, very strong short term bias may result from geomagnetically induced currents (GICs). In recent years, the power transformer manufacturing industry faces increasing performance requirements regarding DC-bias. Many studies were focussed on consequences on the global behaviour of transformers [1], but very little on the magnetic material of the core. The present paper summarizes the main results of an extensive study on multiple effects of bias on the performance of highly grain oriented SiFe. Data is reported from experiments on both samples of material and model cores.

Comparison of simulations of alternating magnetization (AM) and rotational magnetization (RM) on a rotational single sheet tester (RSST) revealed the following tendencies:

(a) Magnetization patterns - Bias yields (usually) small global shifts ΔB of induction patterns $\boldsymbol{B}(t)$ and strong asymmetric enlargements of field patterns $\boldsymbol{H}(t)$ - as an effective measure for ΔB.
(b) Power losses - Bias causes increases that are more pronounced for AM than for RM.
(c) Magnetostriction - Strong increases arise that are much more pronounced for AM than for RM.
(d) Domain configurations - For AM, bias proves to enhance half-cycle annihilation of bar domains, corresponding to half-cycle saturation. For RM, domains are favoured which are magnetized in oblique crystallographic directions.

In order to check the practical relevance of RSST results, model core studies were performed on both 1-phase and 3-phase cores which revealed the following tendencies:

(e) As a general finding, bias yields effects the intensity of which cannot be expressed by the intensity of the involved DC-currents since depending in strongest ways on the “back-flux admittance” *BFA* which mediates DC flux.
(f) *BFA* ranges from minimum values for (i) balanced bias of 3-phase 3-limb cores over (ii) such cores with magnetic surrounding, (iii) cores with unbalanced bias, (iv) 5-limb cores, up to maximum values for (v) 1-phase cores.
(g) The intensity of effects on the core depends on the bias-caused shift ΔB of the induction pattern, in connection with approaching half-cycle saturation.
(h) Even very small ΔB may yield strong increases of peak-to-peak values of excitation, in connection with increased stray field from windings.
(i) Small ΔB yields weak increases of building factor, strong ΔB contributes to hot spots.
(j) Strong ΔB increases stray fields in joint regions thus causing planar eddy currents and loss increases in peripheral core regions.
(k) Even very small ΔB may cause practically relevant increases of audible noise. Vice versa, the noise intensity offers information on the occurrence of bias.

The above means that the results of RSST simulation are widely confirmed by those from model cores. But they are also corresponding to practical industrial experiences.

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[1] PRICE, P.R.: IEEE Trans.Pow.Del., **17**, (2002) 1002.

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