DC-bias on the magnetic performance of transformer core material - A survey

Helmut Pfützner, Georgi Shilyashki, Edin Mulasalihovic, Damir Sabic, Franz Hofbauer, Viktor Galabov

Institute of Electrodynamics, Microwave & Circuit Engineering (EMCE)
University of Technology, Vienna, Austria

The world-wide globalization of electric energy delivery enhances the problem of DC-bias of power transformer cores. This is due to several reasons:

(i) High voltage (HV) lines over extreme distances favour the short-time influx of strong, solar-wind caused, geomagnetically induced currents (GICs) into HV-AC systems [1].

(ii) Long distance HV-DC lines may produce long-term DC-currents in local HV-AC mains.

(iii) Inter-connections between HV-AC systems and HV-DC systems - or HV-AC systems of deviating frequency, respectively - create an increasing demand for thyristor/transistor equipments which may produce long-term DC-currents of weak intensity.

(iv) Extremely large 3-phase power transformers tend to be replaced by sets of three 1-phase transformers which show strongly increased susceptibility to DC-bias.

Influx of DC-current into a power transformer which is part of a rigid HV-system tends to remain without effect on the global AC-magnetization of the magnetic core. This is true for both alternating magnetization (AM) of limbs and rotational magnetization (RM) of T-joints and yokes. However, even small DC-magnetization components in rolling direction favour half-cycle saturation processes. The latter are characterized by the annihilation of bar-domain Bloch walls [2,3] with consequences on the most important characteristics of material.

This yields significant effects as summarized in the following:

(a) The permeability shows distinct decreases linked with high half-cycle increases of field.

(b) The losses for AM tend to increase due to rising hysteresis losses as a result of affected bar domains.

(c) The relative impact of RM on losses sinks due to a priori high hysteresis losses [3].

(d) For AM, magnetostriction-caused strains increase strongly due to enhanced annihilation / nucleation of oblique domains.

(e) For RM, the relative increase of MS-caused strains decreases due to a priori pronounced oblique domain structures [4].

As industrially relevant consequences, DC-bias tends to cause strong increases of excitation currents and stray fields, as well as increases of no-load losses and audible noise.

Acknowledgements - The authors thank for support from the Austrian Science Funds FWF (Project No. P 21546-N22) as well as from ABB Transformers (Ludvika, Sweden).

---

[1] P.R.Price: Geomagnetically induced current effects on transformers. *IEEE Trans.Pow.Del.*17, 1002-1008 (2002).

[2] J.Zbroszczyk, J.Drabecki, B.Wyslocki: Angular distribution of rotational hysteresis losses in Fe-3,25%Si single crystals with orientation (001) and (011). *IEEE Trans.Magn.* 17, 1275-1282 (1981).

[3] H.Pfützner, G.Shilyashki, F.Hofbauer, D.Sabic, E.Mulasahilovic, V.Galabov: Effects of DC-bias on the loss distribution of a model transformer core. *J.El.Eng*. 61, 126-129 (2010).

[4] G.Shilyashki, H.Pfützner, F.Hofbauer, D.Sabic, V.Galabov: Magnetostriction distribution in a model transformer core. *J.El.Eng*. 61, 130-132 (2010).