THE EFFECT OF DC BIAS AND NOISE ON THE PERFORMANCES OF POWER TRANSFORMER

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THE EFFECT OF DC BIAS AND NOISE ON THE PERFORMANCES OF POWER TRANSFORMER

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LIST OF SYMBOLS

A	area of the laminations core
B	magnetic flux density (T)
B_1	predetermined peak fundamental flux density
B_m	Maximum magnetic flux density (T)
E	the modulus of elasticity in the direction of force
f	the fundamental frequency of the excitation waveform
H	magnetic field intensity (A/m)
I_{ad}	additional exciting current includes dc component
I_{dc}	direct current due to dc bias
I_s	saturation current
I_o	total dc component of exciting current
i_a	the additional
i_{a1}	the fundamental components of i_a
i_{ah}	the high harmonic components of i_a
i_{ex}	the total exciting current
$i_h(t)$	harmonic curren
i_{mn}	the normal fundamental excitation current
K_{dc}	DC bias factor
K_s	saturation factor
K_v	coefficient which depends on level of magnetization, the clamping stress

M knee point

M magnetization

N saturation point

N_1 number of the primary turn

K_e Eddy current constant

K_h Hysteresis constant

k_1 & k_2 gradients of piecewise magnetizing characteristic

P_{dc} losses due to load current on dc winding resistance

P_{EC} winding eddy losses (W)

$p_h(t)$ harmonic losses

P_{NL} no load losses (W)

P_{OSL} other stray losses in clamp, tanks, etc.

P_{LL} load losses (W)

P_T total losses (W)

t thickness of lamination strips

$v_h(t)$ harmonic voltage

W_e Eddy current losses (W)

W_h Hysteresis losses (W)

ϵ_t the coefficient depends on the instantaneous value of flux density

Φ_{ac} ac flux produced by ac current

Φ_{dc} dc flux produced by dc current

$\Phi = \Phi_{ac} + \Phi_{dc}$ total flux in the iron core

Φ_s saturation flux

θ the minimum angle in one cycle at which $\Phi = \Phi_s$

μ_o free space (vacuum) permeability (1.256 x 10^{-6} H/m or = 4 π 10^{-7} H/m)

μ_r relative permeability

μ_c core material permeability

η Steinmetz constant

χ_m magnetic susceptibility

$\Re_a$ air reluctance

$\Re_c$ core reluctance

Kesan Bias Arus Terus dan Hingar Bising pada Prestasi Alatubah Tenaga

ABSTRAK

Arus terus dapat dijumpai dalam sebuah gulungan alatubah akibat ketidaksempurnaan sambungan kelengkapan seperti penggunaan peranti-peranti elektronik kuasa dan juga disebabkan gangguan magnetik medan bumi sebagai arus teraruh secara geomagnetic (GIC). Terdapat sejumlah kesan yang sangat mudarat yang berpotensi menyertai keberadaan arus terus dalam sebuah gulungan alatubah, seperti peningkatan pengenalan melampau herotan harmonik voltan dan arus, peningkatan kehilangan tenaga, tepuan setengah-kitar dari teras alatubah dan peningkatan pancaran bising akustik. Penyelidikan ini melibatkan gabungan simulasi MATLAB dan kerja-kerja ujikaji. Berdasarkan simulasi program MATLAB, keputusan menunjukkan bahawa arus penguja menjadi lebih terherot dan condong menepu setengah-kitar ketika arus terus bias meningkat dari 0.2 T sampai 2.0 T dengan tahap tepu maksima dari ketumpatan fluks magnet ulangalik dimisalkan 2.0 T. Ujikaji makmal dilakukan pada sebuah alatubah tenaga satu fasa berskala makmal. Harmonik-harmonik pengujaan yang terhasil dari bias arus terus dan paras hingar yang dipancarkan oleh teras alatubah diselidiki. Bias arus terus disuntik bersamaan dengan punca arus ulangalik bagi keadaan tidak berbeban, sementara, melalui penerus setengah-gelombang beban bervariasi bagi keadaan berbeban. Dengan bias arus terus, alatubah cenderung menjadi tepuan setengah-kitar dan paras harmonik menjadi tinggi. Bentuk gelombang simulasi selari dengan bentuk gelombang dari ujikaji. Keberadaan bias arus terus ditandai dengan tertib sifar and harmonik- harmonik tertib genap secara bererti disamping harmonik-harmonik tertib ganjil. Harmonik-harmonik banyak menyumbang kepada kebisingan alatubah. Ketumpatan fluks magnetik yang lebih tinggi menghasilkan harmonik dan hingar yang lebih tinggi seperti 65.5, 68.4 and 72.4 dB untuk 1.3 T (teruja kurang), 1.5 T (kendalian normal) dan 1.9 T (teruja lebih). Secara keseluruhan, kehilangan tenaga dan harmonik-harmonik adalah lebih rendah untuk pertindihan teras yang pendek dan pelapisan teras lebih tipis. Hasil dari penyelidikan ini menyumbang kepada pemahaman alatubah sebagai punca harmonik dan hingar semasa keberadaan arus terus bias.

The Effect of DC Bias and Noise on the Performances of Power Transformer

ABSTRACT

Direct current can be found in a transformer's winding as a result of imperfections in connected equipment such as power electronics devices used and also due to magnetic disturbances of the earth's field as geomagnetically induced currents (GIC). There are some host adverse effects that can potentially accompany the presence of direct current in a transformer's windings, such as increased introducing extremely large voltage and current harmonic distortion, increased power losses, half-cycle saturated of the transformer core and elevated increasing of acoustic noise emission. This research involved the combination of MATLAB simulation and experimental works. Based on MATLAB program simulation, the results demonstrate that the exciting current becomes much more distort and will incline to half-circle saturation when the DC bias increases from 0.2 T to 1.0 T with the maximum saturation limit of AC magnetic flux density assumed as 2.0 T. A laboratory test is performed on lab-scale single phase power transformer. Excitation harmonics generated from dc biased and noise levels emitted by transformer core are investigated. The DC bias was injected simultaneously with AC source for no-load condition, meanwhile, through half wave rectifier with variable load for load situation. With DC bias, the transformer is prone to half-cycle saturated and rich harmonics are introduced. The simulated waveforms have good agreement with the measured one. The existence of DC bias was signified with zero and the significantly of even order harmonics beside of odd order harmonics. The harmonics contribute most to transformer noise. The higher magnetic flux density produces large harmonic and also higher noise such as 65.5, 68.4 and 72.4 dB for 1.3 T (under excited), 1.5 T (normal operation) and 1.9 T (over excited). The overall power losses and harmonics is lower for smaller core overlap length and thinner thickness of core lamination. The results of this study contribute in understanding transformers as harmonic and noise sources during DC bias existence.