

Analisis Pengaruh Arus Harmonik Terhadap Rugi Daya dan Susut Umur pada Transformator Stasiun MRT Bundaran HI PT. MRT Jakarta = Analysis of the Effect of Harmonic Currents on Power Losses and Lifespan of the MRT Station Transformer at Bundaran HI PT. MRT Jakarta

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Abstrak

Arus harmonik yang dihasilkan oleh beban non-linear pada Stasiun MRT Bundaran HI dapat menyebabkan gangguan pada sistem distribusi tenaga listrik, termasuk peningkatan rugi daya, pemanasan berlebih, dan percepatan penyusutan umur transformator. Penelitian ini bertujuan untuk menganalisis pengaruh arus harmonik terhadap rugi daya, kapasitas pembebanan maksimum, dan susut umur transformator di Stasiun MRT Bundaran HI. Pengukuran dilakukan selama tujuh hari untuk memperoleh data THDi, IHDi, suhu hotspot, dan suhu lingkungan. Hasil menunjukkan bahwa meskipun nilai TDDi memenuhi standar IEEE 519-2022, mayoritas IHDi pada ketiga fasa melebihi batas standar, dengan orde dominan pada harmonik ke-3, 5, 7, 11, dan 13. Hal ini menyebabkan peningkatan rugi daya total sebesar 18.77%, terutama pada rugi arus eddy yang meningkat 1617.13%. Kapasitas pembebanan transformator juga menurun hingga hanya 52.77% dari kapasitas nominal saat THDi tertinggi. Selain itu, perhitungan susut umur menggunakan pendekatan termal IEC 60076-12 menunjukkan bahwa selama 8 tahun masa operasi, trafo telah kehilangan umur sekitar 1.43 hari. Meskipun nilai susut umur relatif kecil, harmonik tetap terbukti memberikan kontribusi terhadap degradasi performa transformator. Faktor suhu ruangan yang stabil turut membantu menjaga suhu hotspot tetap rendah. Untuk itu, disarankan pemasangan Active Harmonic Filter (AHF) guna menurunkan IHDi secara menyeluruh untuk meminimalisir rugi daya tambahan dan panas berlebih, serta melakukan pemantauan suhu belitan dan lingkungan secara berkala agar keandalan transformator tetap terjaga.

.....Harmonic currents generated by non-linear loads at Bundaran HI MRT Station can cause disturbances in the power distribution system, including increased power losses, overheating, and accelerated transformer aging. This study aims to analyze the impact of harmonic currents on power losses, maximum loading capacity, and transformer loss of life at Bundaran HI MRT Station. Measurements were carried out over a period of seven days to collect data on THDi, IHDi, hotspot temperature, and ambient temperature. The results show that although the TDDi values comply with the IEEE 519-2022 standard, the majority of IHDi values in all three phases exceed the permissible limits, with dominant orders ranging from the 3rd, 5th, 7th, 11th, and 13th harmonics. This condition leads to an increase in total power losses by 18.77%, particularly in eddy current losses, which increased by 1617.13%. The maximum loading capacity of the transformer also decreased significantly, with only 52.77% of its rated capacity achievable under the highest THDi condition. Furthermore, life expectancy calculations using the IEC 60076-12 thermal model show that the transformer has lost approximately 1.43 days of its operational life over eight years of service. Although the estimated loss of life appears relatively small, harmonic currents have been proven to contribute to the degradation of transformer performance. The stable ambient temperature helped maintain a low hotspot temperature. Therefore, it is recommended to install an Active Harmonic Filter (AHF) to reduce IHDi

comprehensively, minimize additional power losses and excessive heat, and conduct periodic monitoring of winding and ambient temperatures to ensure transformer reliability is maintained.