INTISARI

PENGUKURAN KOEFISIEN MUAI TERMAL PADA KABEL LISTRIK MENGGUNAKAN MIKRORADIOGRAFI SINAR-X DIGITAL

Oleh:
Yessi Affriyenni
15/388401/PPA/04840

Kabel listrik merupakan medium untuk menghantarkan energi listrik. Kabel listrik memiliki karakteristik tertentu yang disebut Kemampuan Hantar Arus (KHA) yang dipengaruhi oleh berbagai faktor lingkungan seperti suhu. Pemuaian dan penyusutan yang disebabkan oleh perubahan suhu dapat menyebabkan efek *aging* pada kabel yang selanjutnya dapat menyebabkan kerusakan.

Pada penelitian ini, pengamatan muai, pengukuran perubahan geometris akibat perubahan suhu, dan penentuan koefisien muai linier telah dilakukan menggunakan mikroradiografi sinar-x digital di Laboratorium Grup Riset Fisika Citra, Departemen Fisika, Universitas Gadjah Mada. Objek pada penelitian ini adalah kabel NYA, NYAF, dan NYM dengan ukuran luas penampang masing-masing adalah 1,5 mm^2 dan 2,5 mm^2. Perubahan suhu dimonitor menggunakan sensor DS18B20 yang terhubung dengan suatu mikrokontroler. Sebelum proses pengolahan dan analisis, citra dikoreksi dan dinormalisasi menggunakan *software ImageJ*. Analisis visual dilakukan melalui metode selisih citra dan korelasi citra. Analisis fisis dilakukan dengan menggunakan *plugins Adrian's FWHM* pada *software ImageJ* untuk menentukan pergeseran tepi citra. Metode kuadrat terkecil *(Least Square Fit*) digunakan untuk menentukan koefisien muai linier.

Sistem mikroradiografi sinar-x yang telah dikembangkan dapat digunakan untuk mengamati pemuaian logam konduktor kabel akibat proses pemanasan. Melalui pengukuran dan analisis yang dilakukan diperoleh nilai koefisien muai linear masing-masing kabel untuk NYA 1,5 $(16{,}6\pm0{,}5)\times10^{-6}/^{o}C$, NYA 2,5 $(17\pm1)\times10^{-6}/^{o}C$, NYAF 1,5 $(16{,}6\pm0{,}2)\times10^{-6}/^{o}C$, NYAF 2,5 $(16{,}6\pm0{,}4)\times10^{-6}/^{o}C$, NYM 1,5 biru $(16{,}7\pm0{,}2)\times10^{-6}/^{o}C$, NYM 1,5 hitam $(16{,}2\pm0{,}3)\times10^{-6}/^{o}C$, NYM 2,5 biru $(17{,}1\pm0{,}4)\times10^{-6}/^{o}C$, dan NYM 2,5 hitam $(16{,}9\pm0{,}6)\times10^{-6}/^{o}C$ berturut-turut. Uji-*t* menunjukkan bahwa $|t_0| < t_{0.025,12}$ yang berarti bahwa tidak terdapat perbedaan rata-rata pemuaian panjang antar tiap jenis kabel dengan *confidence interval* 95%.

Kata kunci: kabel, pemuaian termal, korelasi citra, mikroradiografi digital, sinar-x, *ImageJ*

ABSTRACT

MEASUREMENT OF THERMAL EXPANSION COEFFICIENT ON ELECTRIC CABLE USING X-RAY DIGITAL MICRORADIOGRAPHY

By:
Yessi Affriyenni
15/388401/PPA/04840

Electric cable is a medium to conduct electrical energy. The electric cable is characterized by its current conducting capability (ampacity). The ampacity is affected by the environmental factors such as temperature. Expansion and contraction caused by thermal changes may result in an aging effect on the cable. Furthermore, it may cause damage.

This work presents the way to observe the expansion and measure geometrical changes in electrical cable due to the changes of temperature using the x-ray micro-digital radiography in the Department of Physics, Gadjah Mada University Yogyakarta. The type of the electric cables for this study was NYA, NYAF, and NYM, which each has two cross-sectional area of 1.5 mm^2 and 2.5 mm^2. The temperature changes were monitored using a DS18B20 waterproof temperature sensor. The sensor has been compiled into the microcontroller. In order to process and analyze the radiography images of the cables, an *ImageJ* software was used. Prior, the images were corrected and normalized to enhance the visibility and image sharpness. Image analysis was conducted based on visual analysis and physical analysis. Visual analysis was conducted based on image elongation following temperature increment. The image differences were compared based on the value of the digital image correlation (DIC). The physical analysis was carried out based Adrian's FWHM to determine the initial and final pixel position of the edges due to temperature change after the heating process. Metals expansion coefficients of the cables were determined using least square fit method (regression method).

The developed x-ray microradiography system has been attempted to use for observing metal expansion due to the heating process based on the radiographs. Through careful measurement and analysis, it is possible to measure the linear thermal expansion coefficient values of NYA 1.5 $(16.6\pm0.5)\times10^{-6}/^{o}C$, NYA 2.5 $(17\pm1)\times10^{-6}/^{o}C$, NYAF 1.5 $(16.6\pm0.2)\times10^{-6}/^{o}C$, NYAF 2.5 $(16.6\pm0.4)\times10^{-6}/^{o}C$, NYM 1.5 blue $(16.7\pm0.2)\times10^{-6}/^{o}C$, NYM 1.5 black $(16.2\pm0.3)\times10^{-6}/^{o}C$, NYM 2.5 blue $(17.1\pm0.4)\times10^{-6}/^{o}C$, and NYM 2.5 black $(16.9\pm0.6)\times10^{-6}/^{o}C$. The *t*-test shows that $|t_0| < t_{0.025,12}$ which means that there is no difference in mean length expansion among cable types for 95% confidence interval.

Keywords: cable, thermal expansion, image correlation, digital microradiograph, x-ray, *ImageJ*