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Metode Continuous Wavelet Transform (Cwt) Pada Sinyal Echo Ultrasonik Untuk Pengukuran Signal Propagation Velocity Dan Acoustic Impedance Pada Material Hebel Dan Kayu
ZHAFAAT RAHIMI ZAINAL, Dr. Danang Lelono, S.Si, M.T.; Oskar Natan, S.ST., M.Tr.T., Ph.D.
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INTISARI

Metode *Continuous Wavelet Transform* (CWT) Pada Sinyal *Echo* Ultrasonik Untuk Pengukuran *Signal Propagation Velocity* Dan *Acoustic Impedance* Pada Material Hebel Dan Kayu

Oleh

Zhafaat Rahimi Zainal, S.Si

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Setiap material memiliki karakteristik fisik yang dapat diidentifikasi melalui parameter *signal propagation velocity* (C) dan *acoustic impedance* (Z) ultrasonik. Penelitian ini bertujuan membandingkan metode *Fast Fourier Transform* (FFT), *Continuous Wavelet Transform* (CWT) Modulus Maxima, dan metode usulan *Energy Peak Consistency* (EPC) berbasis CWT Morlet untuk mendeteksi *onset* sinyal *echo* ultrasonik serta mengkarakterisasi material hebel dan kayu. Penelitian menggunakan pendekatan *Non-Destructive Testing* (NDT) dengan teknik *ultrasonic through-transmission*. Nilai *Time of Flight* (ToF) hasil deteksi digunakan untuk menghitung *signal propagation velocity* dan *acoustic impedance*, sedangkan energi wavelet dianalisis sebagai indikator keberadaan cacat.

Hasil validasi pada media udara menunjukkan bahwa metode EPC menghasilkan akurasi 99,51%, lebih tinggi dibandingkan FFT (86,69%) dan CWT Modulus Maxima (44,29%). Pada material hebel, rata-rata *signal propagation velocity* untuk kondisi normal, pembanding, dan berlubang berturut-turut sebesar 606,68 m/s, 561,08 m/s, dan 635,46 m/s, dengan *acoustic impedance* sebesar 0,3288 MRayl, 0,3030 MRayl, dan 0,3480 MRayl. Pada material kayu diperoleh *signal propagation velocity* sebesar 1165,11 m/s, 1184,59 m/s, dan 1898,42 m/s, serta *acoustic impedance* sebesar 0,4330 MRayl, 0,4217 MRayl, dan 0,6208 MRayl. Analisis menunjukkan bahwa perubahan *signal propagation velocity* dan *acoustic impedance* pada hebel relatif kecil, sedangkan pada kayu jauh lebih signifikan. Selain itu, energi maksimum CWT lebih sensitif terhadap keberadaan lubang, ditunjukkan oleh penurunan 38,06% pada hebel dan peningkatan 169,88% pada kayu. Hasil penelitian menunjukkan bahwa kombinasi metode EPC dan analisis energi wavelet mampu meningkatkan karakterisasi material serta deteksi cacat internal pada sistem NDT ultrasonik.

Kata Kunci: Ultrasonik, *Time of Flight*, Transformasi Wavelet, *Non-Destructive Testing*.

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ABSTRACT

Continuous Wavelet Transform (CWT) Method For Ultrasonic Echo Signal Analysis In Signal Propagation Velocity And Acoustic Impedance Measurements Of Hebel And Wood Materials

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Each material possesses distinct physical characteristics that can be identified through ultrasonic signal propagation velocity (C) and acoustic impedance (Z). This study aims to compare the Fast Fourier Transform (FFT), Continuous Wavelet Transform (CWT) Modulus Maxima, and the proposed Energy Peak Consistency (EPC) method based on Morlet CWT for ultrasonic echo onset detection and the characterization of aerated concrete (hebel) and wood. The study employed a Non-Destructive Testing (NDT) approach using the ultrasonic through-transmission technique. The detected Time of Flight (ToF) was used to calculate the signal propagation velocity and acoustic impedance, while wavelet energy was analyzed as an indicator of internal defects.

The validation results in air demonstrated that the EPC method achieved the highest accuracy of 99.51%, outperforming FFT (86.69%) and CWT Modulus Maxima (44.29%). For aerated concrete, the average signal propagation velocity of the normal, reference, and hollow specimens was 606.68 m/s, 561.08 m/s, and 635.46 m/s, respectively, with corresponding acoustic impedance values of 0.3288 MRayl, 0.3030 MRayl, and 0.3480 MRayl. For wood, the average signal propagation velocity was 1165.11 m/s, 1184.59 m/s, and 1898.42 m/s, while the corresponding acoustic impedance values were 0.4330 MRayl, 0.4217 MRayl, and 0.6208 MRayl. The results indicate that changes in signal propagation velocity and acoustic impedance were relatively small in aerated concrete but considerably larger in wood. Furthermore, the maximum CWT energy exhibited higher sensitivity to the presence of holes, as indicated by a 38.06% decrease in aerated concrete and a 169.88% increase in wood. These findings demonstrate that the combination of the Energy Peak Consistency method and wavelet energy analysis enhances material characterization and internal defect detection in ultrasonic Non-Destructive Testing (NDT).

Keywords: Ultrasonic, Time of Flight, Wavelet Transform, Non-Destructive Testing (NDT).