

Degradasi akibat korosi pada struktur baja yang terpapar lingkungan kombinasi pesisir–industri merupakan tantangan penting terhadap kinerja struktur jangka panjang dan perencanaan pemeliharaan. Penelitian ini menawarkan kebaruan berupa integrasi langsung data lapangan ke dalam dua pendekatan prediksi umur layan yang sebelumnya umumnya diterapkan secara terpisah. Objek penelitian adalah struktur baja pada bangunan *Electrostatic Precipitator* (ESP) di pembangkit listrik tenaga uap berbahan bakar batu bara, dengan tujuan mengevaluasi kondisi struktur, perubahan kinerja akibat korosi, serta memprediksi sisa umur layan berdasarkan pendekatan berbasis korosi dan berbasis kondisi.

Metode penelitian meliputi inspeksi visual, pemetaan korosi, pengukuran ketebalan menggunakan *Ultrasonic Thickness Gauge*, serta uji kekerasan material. Selain itu, dilakukan analisis struktur menggunakan indikator rasio interaksi P-M-M untuk mengevaluasi perubahan tingkat utilisasi elemen akibat pengurangan ketebalan penampang. Data hasil inspeksi kemudian dianalisis menggunakan dua pendekatan, yaitu *corrosion-based assessment* berdasarkan ISO 9224 untuk memperkirakan *Remaining Service Life* (RSL) dan *condition-based assessment* berdasarkan ISO 15686 untuk memperkirakan *Remaining Useful Life* (RUL).

Hasil penelitian menunjukkan bahwa korosi memengaruhi seluruh elemen struktur, dengan *bracing* mengalami degradasi paling parah, diikuti oleh balok, sedangkan kolom menunjukkan tingkat kerusakan yang relatif lebih rendah. Elemen balok dan *bracing* memiliki laju korosi yang lebih tinggi, pengurangan ketebalan yang lebih besar, serta estimasi umur layan yang lebih pendek dibandingkan kolom. Temuan ini sejalan dengan hasil analisis rasio interaksi P-M-M, di mana *bracing* mengalami peningkatan nilai P-M-M paling besar hingga terdapat elemen yang mencapai kondisi *overstressed*. Perbandingan antara RSL dan RUL menunjukkan kecenderungan hasil yang konsisten dalam mengidentifikasi komponen struktur yang paling kritis, sehingga menegaskan keandalan integrasi penilaian berbasis korosi dan berbasis kondisi. Kerangka kerja yang diusulkan memungkinkan evaluasi degradasi struktur secara cepat, praktis, dan berbasis data lapangan dengan mengintegrasikan penilaian kondisi, analisis rasio interaksi P-M-M, dan prediksi sisa umur sebagai dasar penentuan prioritas inspeksi dan strategi pemeliharaan pada struktur baja PLTU di lingkungan pesisir–industri.

Kata kunci: Korosi Atmosferik, Prediksi Sisa Umur, ISO 9224, ISO 15686, Electrostatic Precipitator

ABSTRACT

Corrosion-induced degradation of steel structures exposed to combined coastal–industrial environments poses a significant challenge to long-term structural performance and maintenance planning. This study presents a novel framework by directly integrating field inspection data into two service life prediction approaches that have generally been applied separately. The research focuses on the steel structure of an Electrostatic Precipitator (ESP) building at a coal-fired power plant, aiming to evaluate structural condition, assess changes in structural performance due to corrosion, and predict the remaining service life using both corrosion-based and condition-based approaches.

The research methodology includes visual inspection, corrosion mapping, thickness measurement using an Ultrasonic Thickness Gauge (UTG), material hardness testing, and structural analysis using the axial force–bending moment–bending moment (P-M-M) interaction ratio to evaluate changes in member utilization caused by corrosion-induced thickness reduction. The inspection data were analyzed using two approaches: (1) a corrosion-based assessment in accordance with ISO 9224 to estimate the Remaining Service Life (RSL), and (2) a condition-based assessment based on ISO 15686 to estimate the Remaining Useful Life (RUL).

The results indicate that corrosion affected all structural members, with bracing experiencing the most severe degradation, followed by beams, while columns exhibited relatively lower deterioration. Beams and bracing showed higher corrosion rates, greater thickness reduction, and shorter estimated service lives than columns. These findings are consistent with the P-M-M interaction ratio analysis, in which bracing exhibited the greatest increase in the P-M-M ratio, with several members reaching an overstressed condition. Furthermore, the comparison between RSL and RUL consistently identified the most critical structural members, confirming the reliability of integrating corrosion-based and condition-based assessments. The proposed framework enables rapid, practical, and field data-based evaluation of structural degradation by integrating condition assessment, P-M-M interaction ratio analysis, and service life prediction. This framework provides a practical decision-support tool for establishing inspection priorities and maintenance strategies for existing steel structures in coal-fired power plants exposed to aggressive coastal–industrial environments.

Keywords: Atmospheric Corrosion, Remaining Useful Life, ISO 9224, ISO 15686, Electrostatic Precipitator