

ABSTRAK

ANALISIS KEGAGALAN *WATERWALL TUBE* AKIBAT ABRASI BERDASARKAN LAJU PENIPISAN DINDING DAN ESTIMASI SISA UMUR PAKAI PADA *BOILER*

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(2026: xv + 52 Halaman, 9 Gambar, 10 Tabel, 5 Lampiran)

Penelitian ini bertujuan menganalisis kegagalan *waterwall tube* Unit 2 Boiler PLTU 3×10 MW PT Bukit Energi Servis Terpadu (PT BEST) Tanjung Enim berdasarkan laju penipisan dinding (*corrosion rate*/CR), estimasi sisa umur pakai (*remaining life assessment*/RLA), serta perubahan struktur mikro material. Penelitian ini menggunakan metode kuantitatif dengan pendekatan studi kasus. Pengukuran ketebalan dilakukan pada 177 pipa yang tersebar pada 4 sisi boiler dan 6 titik elevasi menggunakan *Ultrasonic Thickness Gauge* (UTG), sedangkan perubahan struktur mikro diamati melalui pengujian metalografi pada sampel baru, sampel degradasi bagian luar, dan sampel degradasi bagian dalam. Ketebalan minimum yang diizinkan dihitung berdasarkan ASME Section I dengan tekanan operasi 5,20 MPa serta standar internal PT BEST, sehingga diperoleh nilai *t*-min masing-masing sebesar 1,34 mm dan 3,0 mm. Hasil pengukuran menunjukkan ketebalan pipa berkisar antara 1,93–3,88 mm dari ketebalan awal 4,0 mm, dengan kondisi paling kritis ditemukan pada Sisi ESP Elevasi 22 meter Pipa 15 yang memiliki nilai *corrosion rate* sebesar 0,2588 mm/tahun dan *remaining life assessment* berdasarkan ASME sebesar 2,27 tahun. Berdasarkan hasil analisis, sebanyak 170 pipa berstatus aman dan 7 pipa berstatus perhatian menurut standar ASME, sedangkan berdasarkan standar internal PT BEST terdapat 15 pipa yang termasuk kategori kritis. Hasil pengujian metalografi menunjukkan adanya perubahan struktur mikro pada sampel yang mengalami degradasi dibandingkan dengan sampel baru. Hasil tersebut sejalan dengan tindakan PT BEST yang telah melakukan penggantian 13 pipa pada lokasi tersebut. Analisis menunjukkan bahwa mekanisme kegagalan didominasi oleh abrasi akibat tumbukan partikel silika dan *fly ash* pada suhu operasi sekitar 750 °C, sedangkan kualitas air umpan boiler dengan pH 8,5–9,5 tidak memberikan kontribusi signifikan terhadap penipisan dinding pipa.

Kata kunci: *waterwall tube*, abrasi, *corrosion rate*, *remaining life assessment*, boiler.

ABSTRACT

FAILURE ANALYSIS OF WATERWALL TUBES DUE TO ABRASION BASED ON WALL THINNING RATE AND REMAINING LIFE ASSESSMENT IN A BOILER

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(2026: xv + 52 Halaman, 9 Gambar, 10 Tabel, 5 Lampiran)

This study aims to analyze the failure of the *waterwall tube* in Unit 2 Boiler of the 3×10 MW Steam Power Plant at PT Bukit Energi Servis Terpadu (PT BEST), Tanjung Enim, based on the *corrosion rate* (CR), *remaining life assessment* (RLA), and changes in the material's microstructure. This research employed a quantitative method with a case study approach. Wall thickness measurements were carried out on 177 tubes distributed across four boiler sides and six elevation points using an *Ultrasonic Thickness Gauge* (UTG), while microstructural changes were observed through metallographic testing on a new sample, a degraded outer-surface sample, and a degraded inner-surface sample. The minimum allowable thickness was calculated according to ASME Section I under an operating pressure of 5.20 MPa and PT BEST's internal standard, resulting in minimum allowable thicknesses $t_{\min}$ of 1.34 mm and 3.0 mm, respectively. The measurement results indicated that the tube thickness ranged from 1.93 mm to 3.88 mm from the initial thickness of 4.0 mm. The most critical condition was identified at the ESP Side, Elevation 22 m, Tube No. 15, with a *corrosion rate* of 0.2588 mm/year and an ASME-based *remaining life assessment* of 2.27 years. Based on the analysis, 170 tubes were classified as safe and 7 tubes required attention according to the ASME standard, while PT BEST's internal standard classified 15 tubes as critical. Metallographic examination revealed microstructural changes in the degraded samples compared with the new sample. These findings are consistent with PT BEST's decision to replace 13 tubes at the affected location. The analysis indicates that the failure mechanism was primarily caused by abrasion due to the impact of silica particles and *fly ash* at an operating temperature of approximately 750 °C, while the boiler feedwater quality with a pH of 8.5–9.5 did not significantly contribute to wall thinning.

Keywords: *waterwall tube, abrasion, corrosion rate, remaining life assessment, boiler.*