ABSTRAK

Heat Recovery Steam Generator (HRSG) merupakan salah satu komponen vital pada sistem pembangkit listrik tenaga gas dan uap (PLTGU) yang berfungsi memanfaatkan gas buang turbin gas untuk menghasilkan uap. Seiring waktu operasi, HRSG mengalami penurunan performa akibat degradasi material seperti korosi, creep, dan retak pada pipa maupun sambungan las. Evaluasi kondisi material dan estimasi sisa umur menjadi langkah penting untuk menjamin keselamatan, keandalan, serta efisiensi operasi pembangkit.

Penelitian ini bertujuan untuk melakukan penilaian sisa umur HRSG Unit 2 menggunakan pendekatan *in situ metalurgi* sesuai standar ASME FFS-1/API 579. Metode yang digunakan meliputi inspeksi visual, uji tak merusak (*Non-Destructive Testing/NDT*) berupa *Dye Penetrant Test* (DPT), *Magnetic Particle Test* (MPT), *Ultrasonic Thickness Measurement* (UTM), dan *Ultrasonic Flaw Detection* (UFD), serta pengujian pendukung berupa *field metallography*, *hardness test*, *Borescope inspection*, *dimensional examination*, dan analisis beban pada pipa.

Hasil penelitian menunjukkan bahwa ketebalan aktual pipa HRSG masih berada pada kisaran 58–69% dari *Minimum Wall Thickness* (mwt), dengan nilai kekerasan material berkisar 120–220 HV, sesuai dengan standar desain. Analisis mikrostruktur tidak menemukan degradasi signifikan yang berpotensi menyebabkan kegagalan segera. Berdasarkan *Remaining Life Assessment (RLA)*, HRSG Unit 2 masih memiliki estimasi sisa umur operasional sekitar 10–15 tahun, dengan catatan dilakukan pemeliharaan preventif secara konsisten.

Kesimpulan penelitian ini menegaskan bahwa HRSG Unit 2 masih dalam kondisi operasional aman dan reliabel. Pendekatan in situ metalurgi berbasis standar ASME terbukti efektif untuk menilai kondisi aktual, memperkirakan sisa umur, serta memberikan dasar teknis bagi strategi pemeliharaan berbasis risiko yang lebih terarah. Hasil penelitian ini diharapkan dapat mendukung peningkatan *availability*, *reliability*, *efficiency*, dan *safety* pada sistem pembangkit PLTGU.
Kata kunci: *Heat Recovery Steam Generator*, ASME FFS-1/API 579, *in situ metalurgi*, *Remaining Life Assessment*, *Non-Destructive Testing*.

ABSTRACT

The Heat Recovery Steam Generator (HRSG) is a critical component in combined cycle power plants (CCPP) that functions to utilize exhaust gas from gas turbines to generate steam. Over the course of operation, HRSG performance gradually declines due to material degradation mechanisms such as corrosion, creep, and cracking in tubes and welded joints. Therefore, material condition evaluation and remaining life estimation are essential to ensure operational safety, reliability, and efficiency of the power plant.

This study aims to assess the remaining life of HRSG Unit 2 using an in situ metallurgical approach in accordance with the ASME FFS-1/API 579 standard. The methods employed include visual inspection and Non-Destructive Testing (NDT), namely Dye Penetrant Testing (DPT), Magnetic Particle Testing (MPT), Ultrasonic Thickness Measurement (UTM), and Ultrasonic Flaw Detection (UFD). Supporting examinations consist of field metallography, hardness testing, borescope inspection, dimensional examination, and pipe load analysis.

The results indicate that the actual tube thickness of the HRSG remains within 58–69% of the Minimum Wall Thickness (MWT), while material hardness values range from 120 to 220 HV, which are consistent with design standards. Microstructural analysis revealed no significant degradation that could lead to imminent failure. Based on the Remaining Life Assessment (RLA), HRSG Unit 2 is estimated to have an operational remaining life of approximately 10–15 years, provided that preventive maintenance is carried out consistently.

This study concludes that HRSG Unit 2 is still in a safe and reliable operating condition. The ASME-based in situ metallurgical approach is proven to be effective in evaluating the actual condition, estimating remaining life, and providing a solid technical basis for more focused risk-based maintenance strategies. The findings of this study are expected to contribute to improved availability, reliability, efficiency, and safety of combined cycle power generation systems.

Keywords: Heat Recovery Steam Generator, ASME FFS-1/API 579, in situ metallurgy, Remaining Life Assessment, Non-Destructive Testing.