

## ABSTRAK

MUHAMMAD ZIDAN SYAHID. Analisis Kegagalan Material *Tube Superheater* Pada Pembangkit Listrik Tenaga Uap X. Dibimbing oleh PROF. DR.-ING. ANDIKA W. PRAMONO, M.SC.

Kegagalan *tube superheater* merupakan salah satu penyebab utama gangguan operasi pada Pembangkit Listrik Tenaga Uap (PLTU) karena beroperasi pada kondisi temperatur dan tekanan tinggi serta lingkungan pembakaran yang agresif. Penelitian ini bertujuan untuk menganalisis mekanisme kegagalan material *tube superheater* pada PLTU X serta mengidentifikasi faktor dominan penyebab kegagalan berdasarkan bukti metalurgi dan analisis risiko. Metode penelitian yang digunakan meliputi pengujian visual, pengukuran ketebalan, *Positive Material Identification (PMI)*, metalografi, *Scanning Electron Microscopy–Energy Dispersive X-ray Spectroscopy (SEM–EDS)*, uji kekerasan, uji tarik, serta analisis risiko menggunakan *Failure Mode and Effects Analysis (FMEA)*. Hasil penelitian menunjukkan bahwa material *tube superheater* masih memenuhi spesifikasi ASTM SA 213 T12, sehingga kegagalan tidak disebabkan oleh ketidaksesuaian material. Kegagalan terjadi secara bertahap akibat kombinasi penipisan dinding sisi luar, pertumbuhan lapisan oksida internal yang menghambat perpindahan panas, serta paparan temperatur tinggi jangka panjang yang memicu deformasi plastis berupa *bulging* dan berujung pada *fish mouth rupture*. Analisis FMEA menunjukkan bahwa penipisan dinding dan degradasi termal merupakan faktor dengan tingkat risiko tertinggi. Temuan ini menegaskan pentingnya pemantauan ketebalan, pengendalian deposit, dan deteksi dini temperatur logam aktual untuk meningkatkan keandalan *tube superheater*.

**Kata kunci:** kegagalan *tube superheater*, degradasi material, *FMEA*, PLTU

## ABSTRACT

MUHAMMAD ZIDAN SYAHID. *Failure Analysis of Superheater Tube Material at Steam Power Plant X. Supervised by PROF. DR.-ING. ANDIKA W. PRAMONO, M.SC.*

*Superheater tube failure is a major contributor to operational disturbances in steam power plants due to high temperature, high pressure, and aggressive combustion environments. This study aims to analyze the failure mechanism of superheater tube material at Steam Power Plant X and to identify the dominant failure factors based on metallurgical evidence and risk analysis. The research methods include visual inspection, thickness measurement, Positive Material Identification (PMI), metallographic examination, Scanning Electron Microscopy–Energy Dispersive X-ray Spectroscopy (SEM–EDS), hardness testing, tensile testing, and risk assessment using Failure Mode and Effects Analysis (FMEA). The results indicate that the superheater tube material complies with ASTM SA 213 T12 specifications, confirming that the failure was not caused by material selection errors. The failure developed progressively due to a combination of fireside wall thinning, internal oxide scale growth that reduced heat transfer efficiency, and long-term exposure to high temperatures, resulting in plastic deformation and final fish mouth rupture. FMEA results show that wall thinning and thermal degradation have the highest risk priority. These findings highlight the importance of thickness monitoring, deposit control, and early detection of actual metal temperature to improve superheater tube reliability.*

**Keywords:** *superheater tube failure, material degradation, FMEA, steam power plant*