

ABSTRAK

Rizky, Muhammad. 2026. Analisis Kelelahan Sambungan *Fillet Weld* pada *Side Shell* Berbasis *Hotspot Stress* dan *Fracture Mechanics*: Studi Tinjauan Regulasi BKI, Skripsi. Tanjungpinang: Program Studi Teknik Perkapalan, Fakultas Teknik dan Teknologi Kemaritiman, Universitas Maritim Raja Ali Haji. Pembimbing I: Ir. Anton Hekso Yunianto, S.T., M.Si. Pembimbing II: Prof. Indra Putra Almanar, Ph.D.

Kapal pengangkut *Crude Palm Oil (CPO)* menerima beban siklik hidrodinamik secara berulang selama operasi, sehingga memicu kelelahan (*fatigue*) pada sambungan las sudut *fillet weld* yang menghubungkan penumpu melintang *web frame* dengan pelat sisi luar (*side shell*). Penelitian terdahulu umumnya mengevaluasi kelelahan sambungan las hanya melalui satu pendekatan, sehingga integrasi metode *hotspot stress* dan *fracture mechanics* pada struktur lambung ganda kapal CPO masih terbatas. Penelitian ini bertujuan menganalisis sebaran tegangan dan memprediksi umur kelelahan sambungan *fillet weld* pada *side shell* kapal CPO 4000 DWT akibat beban gelombang pada empat klasifikasi daerah pelayaran BKI (Samudera, P, L, dan T). Analisis dilakukan menggunakan metode elemen hingga berbasis sub-modeling pada perangkat lunak ANSYS, dengan ekstraksi hotspot stress melalui ekstrapolasi linear pada titik referensi 0,5t dan 1,5t sesuai BKI *Rules for Hull 2026*, dilanjutkan evaluasi umur kelelahan menggunakan kurva *S-N FAT 90* dan pendekatan *fracture mechanics* berbasis Hukum Paris. Hasil penelitian menunjukkan nilai *hotspot stress* tertinggi pada pelayaran Samudera sebesar 41,55 MPa dan terendah pada pelayaran T sebesar 24,93 MPa. Estimasi siklus inisiasi retak (N_i) berdasarkan kurva S-N berkisar $3,25 \times 10^7$ hingga $1,51 \times 10^8$ siklus, setara 13,00–60,40 tahun, sedangkan estimasi siklus perambatan retak (N_f) berdasarkan *fracture mechanics* berkisar $1,42 \times 10^7$ hingga $5,72 \times 10^7$ siklus, setara 5,68–22,88 tahun. Dibandingkan kriteria umur desain BKI 20 tahun, sambungan pada pelayaran Samudera dan P tidak memenuhi kriteria berdasarkan N_i , sedangkan berdasarkan N_f hanya pelayaran T yang memenuhi kriteria tersebut.

Kata kunci: *Fillet Weld*, *Hotspot Stress*, *Fracture Mechanics*, *Fatigue Life*, Kapal CPO, BKI

ABSTRACT

Rizky, Muhammad. 2026. *Fatigue Analysis of Fillet Weld Joint on Side Shell Based on Hotspot Stress and Fracture Mechanics: A Review Study of BKI Regulation*, Thesis. Tanjungpinang: Naval Architecture Study Program, Faculty of Engineering and Maritime Technology, Maritim Raja Ali Haji University. Supervisor: Ir. Anton Hekso Yunianto, S.T., M.Si. Co-supervisor: Prof. Indra Putra Almanar, Ph.D.

Crude Palm Oil (CPO) carriers are subjected to repeated hydrodynamic cyclic loading during operation, which induces fatigue damage at the fillet weld joint connecting the transverse web frame to the side shell plate. Previous studies have generally evaluated weld joint fatigue using only a single approach, leaving the integration of hotspot stress and fracture mechanics methods on double-hull CPO ship structures largely unexplored. This study aims to analyze the stress distribution and predict the fatigue life of the fillet weld joint on the side shell of a 4,000 DWT CPO ship under wave loading across four BKI navigation area classifications (Unrestricted, P, L, and T). The analysis was performed using a sub-modeling-based finite element method in ANSYS, with hotspot stress extracted through linear extrapolation at reference points 0.5t and 1.5t in accordance with the BKI Rules for Hull 2026, followed by fatigue life evaluation using the FAT 90 S-N curve and a fracture mechanics approach based on Paris' Law. The results show the highest hotspot stress occurs in the Unrestricted area at 41.55 MPa, and the lowest in the T area at 24.93 MPa. The estimated crack initiation cycles (N_i) based on the S-N curve range from 3.25×10^7 to 1.51×10^8 cycles, equivalent to 13.00–60.40 years, while the estimated crack propagation cycles (N_f) based on fracture mechanics range from 1.42×10^7 to 5.72×10^7 cycles, equivalent to 5.68–22.88 years. Against the BKI 20-year design life criterion, the joints in the Unrestricted and P navigation areas fail to meet the criterion based on N_i , while based on N_f , only the T navigation area meets the criterion.

Keywords: Fillet Weld, Hotspot Stress, Fracture Mechanics, Fatigue Life, CPO Ship, BKI